UNIT- 3

AM RECEIVERS

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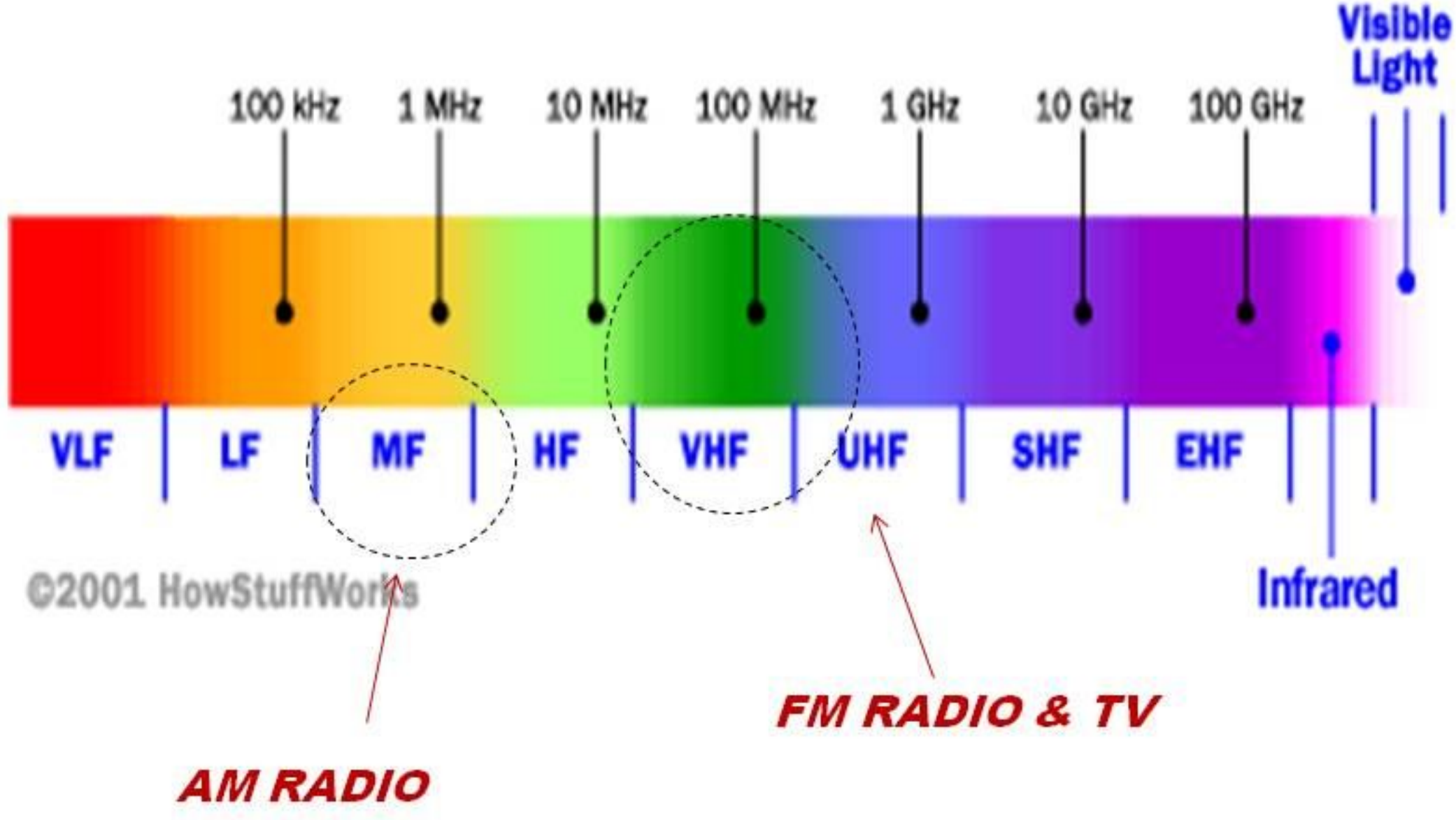
TOPICS(to be covered as per syllabus)

- **AM Receivers:** Classification, Principle of AM Radio Receivers,
- TRF receivers; Practical TRF Receivers, Super heterodyne Receivers,
- Characteristics of Ideal Receiving Aerials, Receiving,
- RF Amplifier Stage, Image Signal Rejection, Receivers Noise, frequency Converter stage,
- Square LAW and Generalized Conversion Theory's,
- Frequency mixers,
- Tracking and Alignment of Receivers for single dial Tuning,
- IF Amplifier,
- detector and AGC Circuits,
- Tone Compensated Volume Control,
- Tuning Control,
- Band-Spread Tuning.
- Noise Limiter,
- AFC, Code Reception,
- SSB Receivers,
- Volume Expanders,
- Diversity Reception- Space and Frequency Diversity MUSA System.

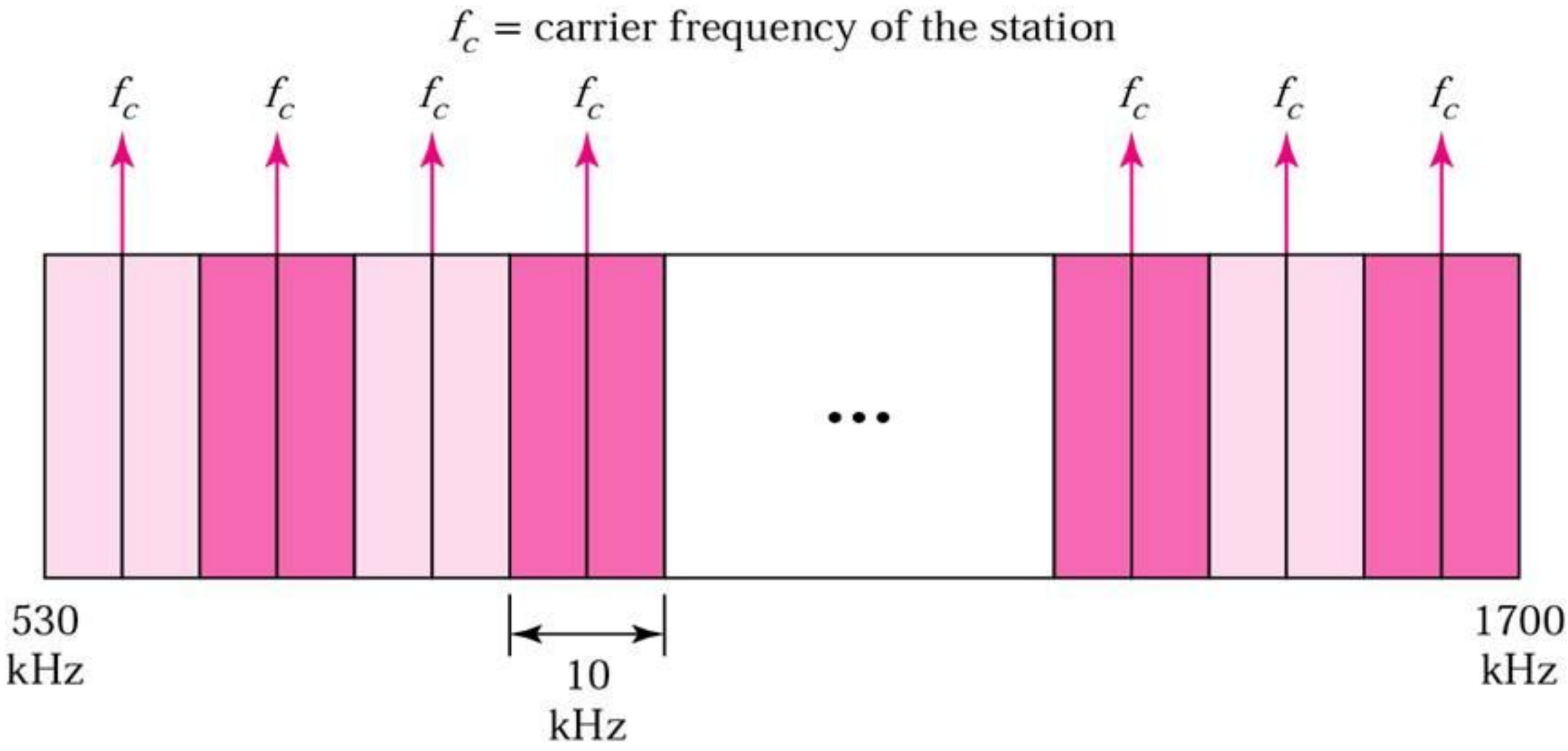
MAIN FUNCTION OF A RADIO RECEIVERS:

- Receives radiated modulated signal or Intercept the incoming modulated signal (i.e ,electromagnetic waves) by the receiving antenna.
- Amplifies the received signal
- Selects the required signal
- Rejects unwanted signals at neighbouring frequencies
- Demodulates the signal to recover original modulating voltages
- Amplify the modulating frequency signal

The radio spectrum:



AM band allocation



Classification of RADIO Receiver:

Classified based on the type of traffic they are designed to handle.

- AM Broadcast Receiver.
- FM Broadcast Receiver.
- T.V Receiver.
- Communication Receivers.
- Code Receivers.
- Radar Receivers.

Based on the technique of operations

- Straight Receivers also called as TRF(Tuned Radio Frequency) Receivers
- Super heterodyne Receivers.

➢ Tuned Radio Frequency (TRF) Receiver

A number of radio frequency amplifiers, all tuning together are employed to:

Select the required incoming signal

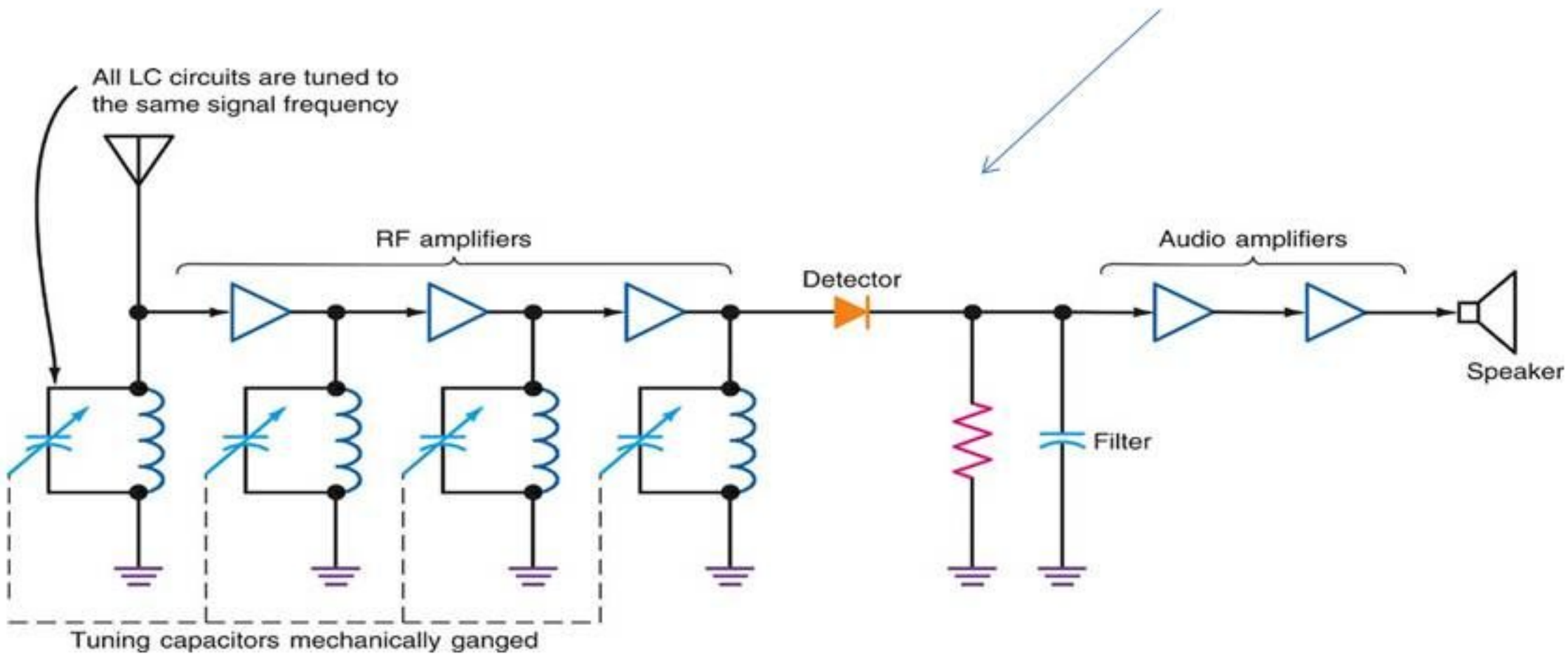
Amplify the selected signal

Simultaneously reject all other signals

Demodulate/detect

Amplify for loudspeaker output

Figure 1: Tuned Radio Frequency (TRF)



Problems with TRF Receiver

- Instability associated with high gain at one frequency in a multistage amplifier (positive feedback - oscillations)

- Variation in bandwidth over the tuning range

- Unable to achieve sufficient selectivity at high frequencies (double tuned circuits required)

Superhetrodyne Receiver

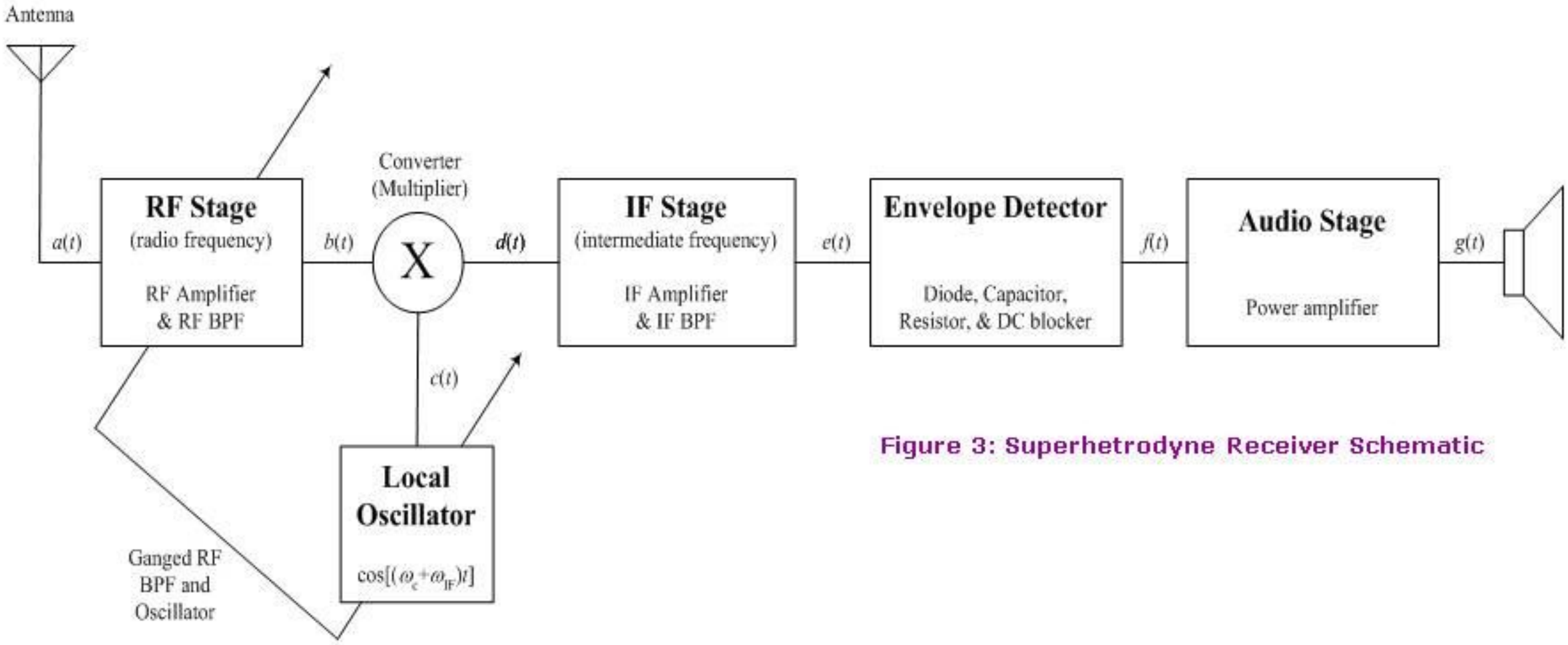
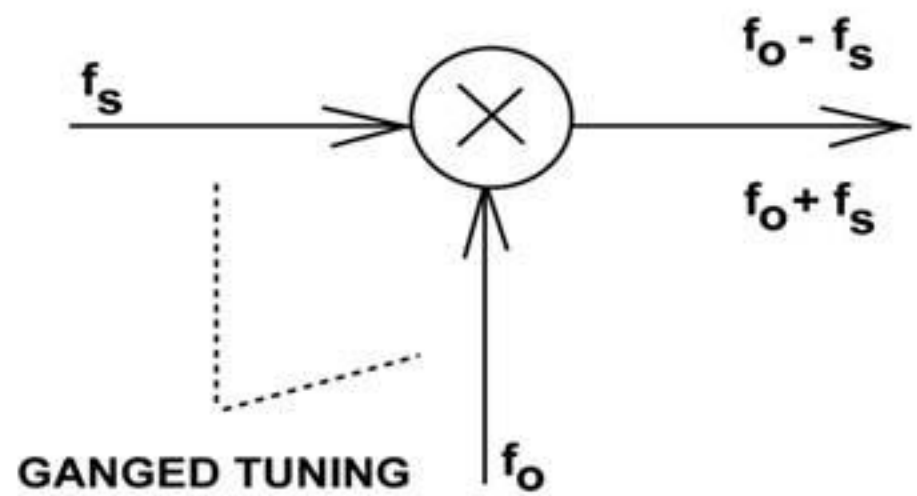


Figure 3: Superhetrodyne Receiver Schematic



Aspects of the superhetrodyne receiver include:

- Incoming signal mixed with local oscillator signal.

- Lower sideband of fixed frequency (intermediate frequency) selected, amplified and detected.

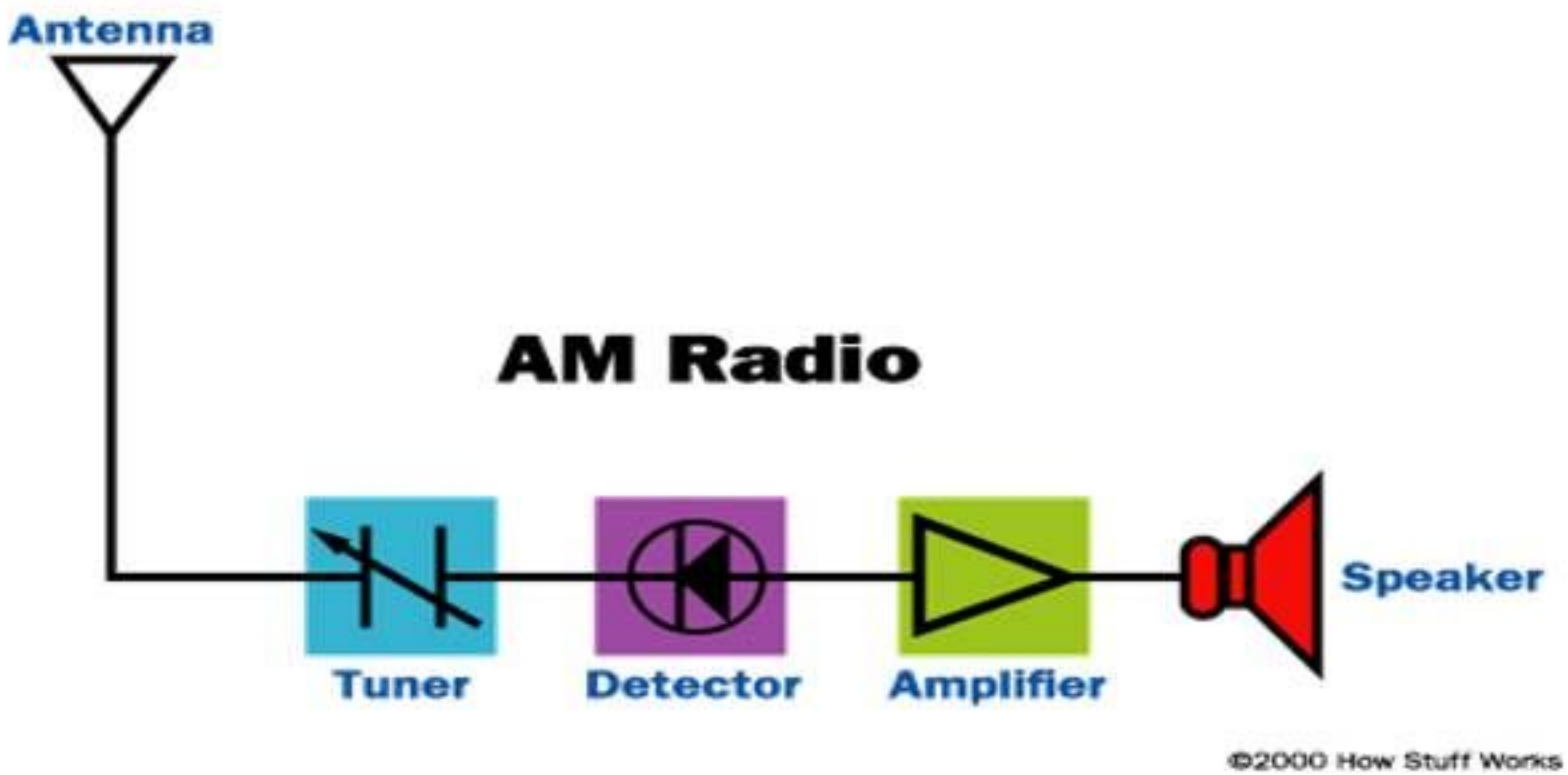
- Constant frequency difference maintained by ganged tuned circuits.

- IF amplifier provides most of the gain and sensitivity.

- IF amplifier characteristics are independent of frequency to which the receiver is tuned

- Selectivity and sensitivity are constant throughout the tuning range

- RF circuits selects the wanted frequency and to reject the adjacent unwanted signals and the image frequency.



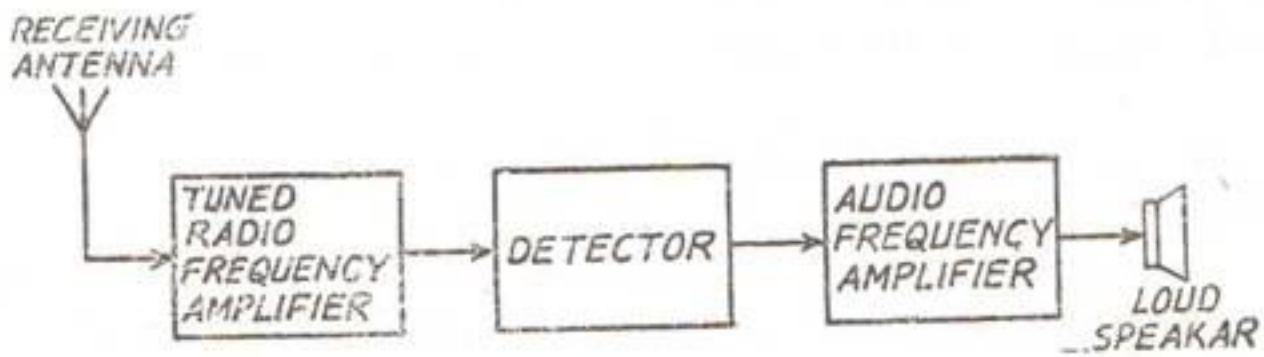
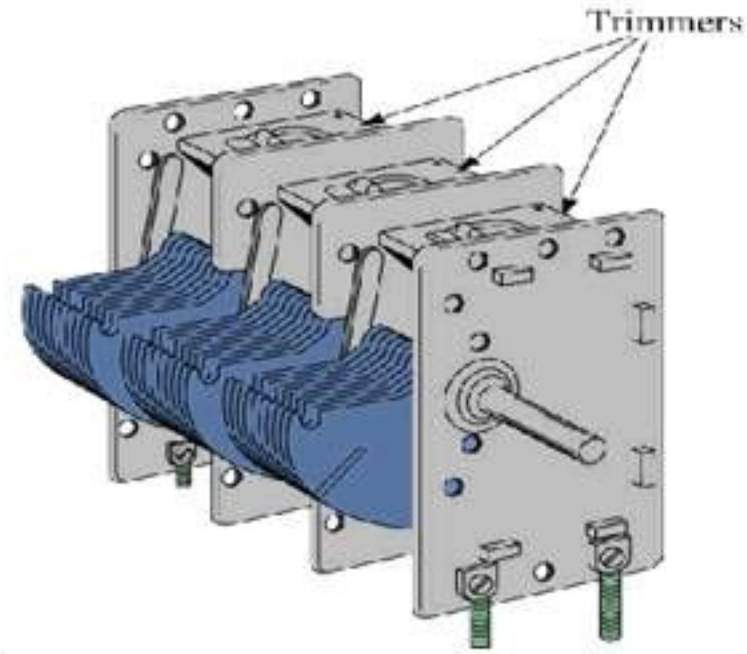
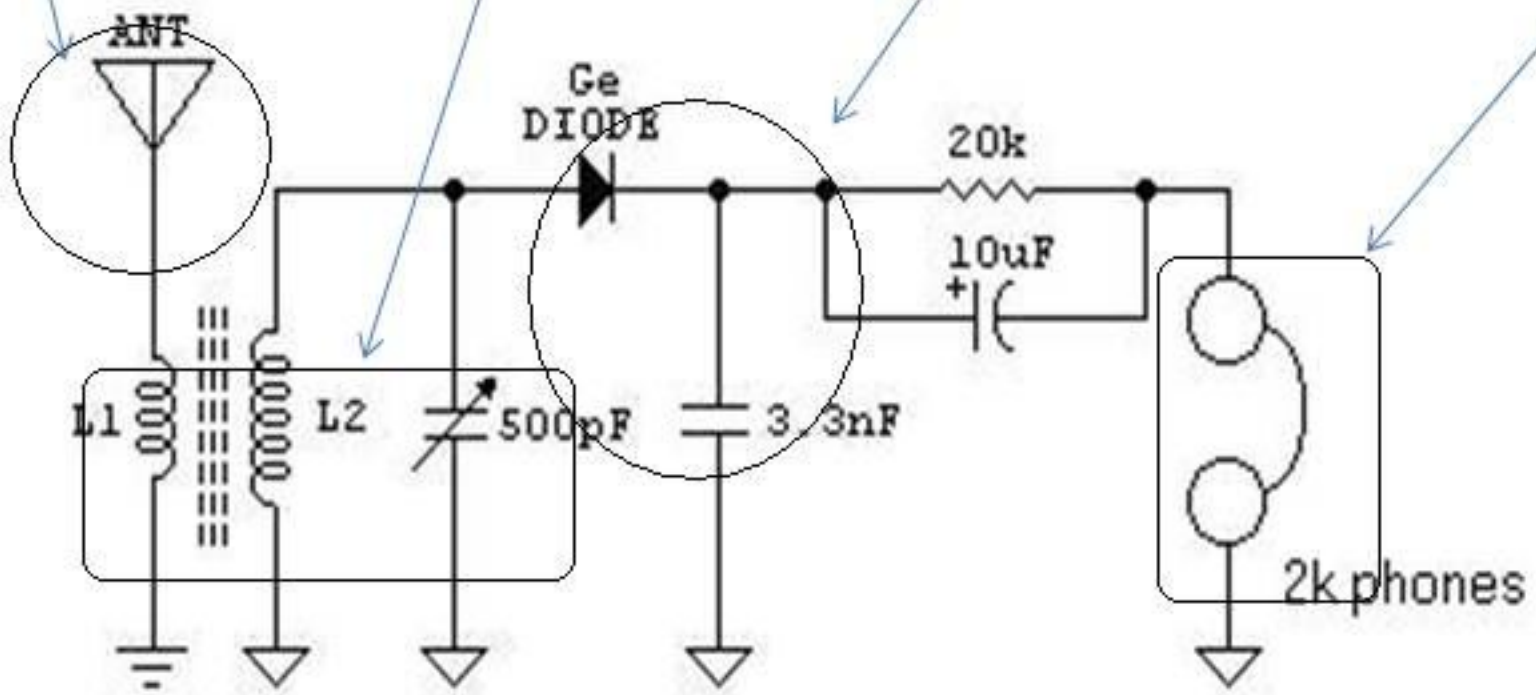


Fig. 9.2. Block diagram of TRF receiver.



Four functions of a receiver:

1. Reception
2. Selection
3. Detection
4. Reproduction



L1: 4 turns of Litz wire (see text).
L2: Main tuning coil - 50 turns of Litz wire (see text).
⏚: Circuit´s common ground
The diode detector is a germanium type.

Fig.1 Basic crystal receiver

Frequency parameters of AM Receiver

1. Two Frequency band : 1. MW(Medium wave band)
   2. SW(Short wave band)
2. RF carrier Frequency range:

   MW(Medium wave band): 530 kHz – 1600 kHz

   Short wave band: 5MHz – 15 MHz
3. Band width of an AM station: 10 kHz per channel(9 kHz in some countries)
4. More that 100 stations can be licensed in the same geographical area.
5. Intermediate Frequency(IF): 455KHz
6. Intermediate Frequency(IF) BW : 10 KHz

Characteristic parameters of a Receiver

- **Sensitivity:** Ability of a receiver to pick up weak signal
- **Selectivity:** Ability of a receiver to select a signal of a desired frequency while rejecting those on closely adjacent frequencies
- **Fidelity:** to reproduce all frequency component at the output
- **Double spotting:** Tuning of 2 stations at a time
- **Tracking:** local oscillator doesn't track or tune properly
  How to Remove Tracking : By Fine tuning

Sensitivity:

1. A communication receiver's sensitivity, or ability to pick up weak signals, is a function of overall gain, the factor by which an input signal is multiplied to produce the output signal.
2. The higher the gain of a receiver, the better its sensitivity.
3. The more gain that a receiver has, the smaller the input signal necessary to produce a desired level of output.
4. High gain in receivers is obtained by using multiple amplification stages.

Selectivity :

1. A receiver with good selectivity will isolate the desired signal and greatly attenuate/eliminates other signals.
2. To improve selectivity is to add stages of amplification, both before and after demodulator

   Eg : Tuned Radio Frequency

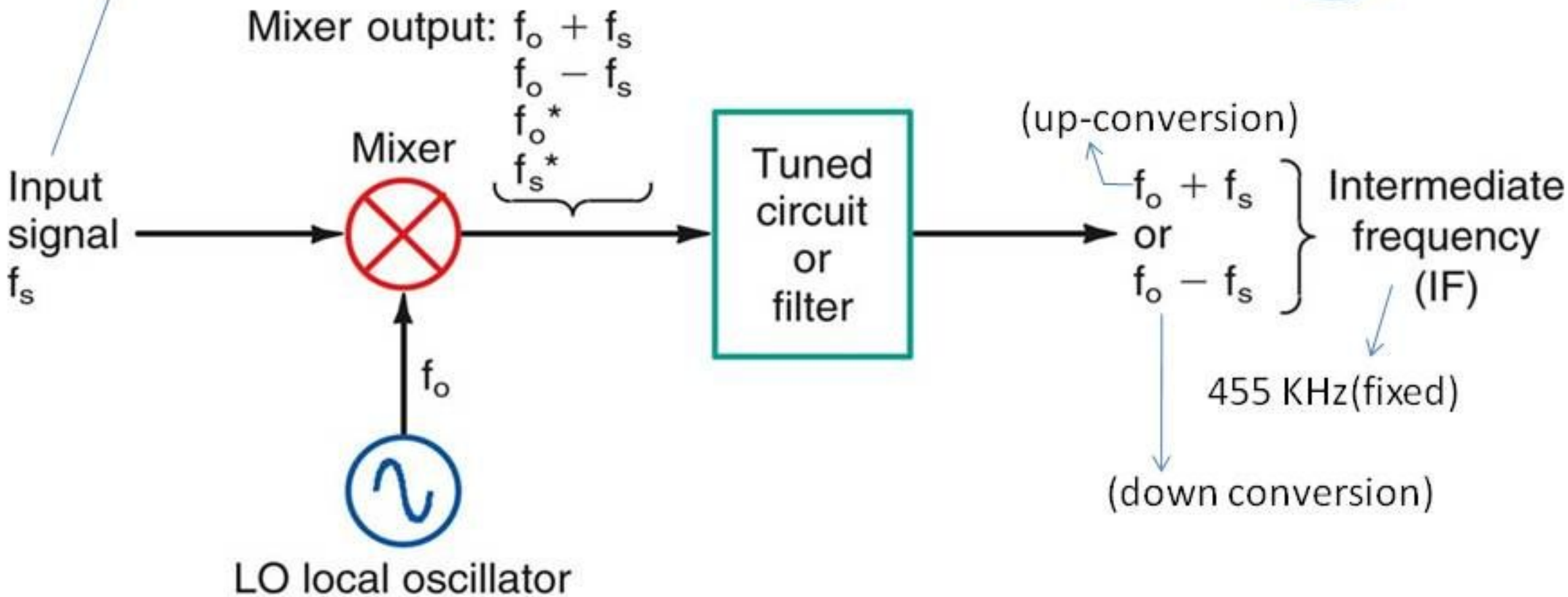
Q. What is the range of frequencies received by a standard AM broadcast receiver?

Ans: 550 kHz to 1650 kHz

Q. State two factors which must be considered by the designer when selecting the IF frequency?

Ans: Separation from the sum frequency

Separation from the image frequency



* May or may not be in the output depending upon the type of mixer.

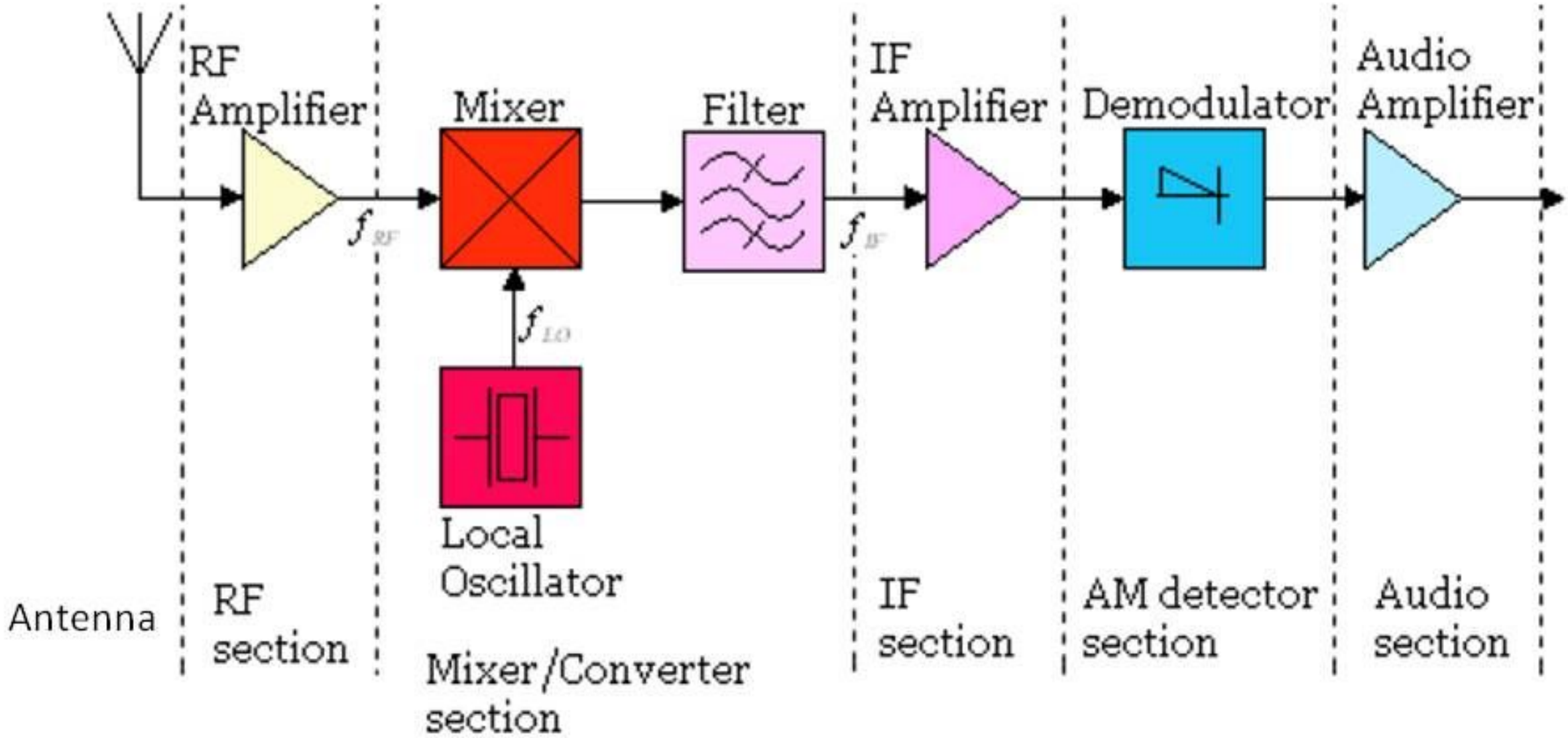


Figure 6-1: AM superheterpdyne receiver and its simplified block diagram

Heterodyne means to mix two frequencies together in a nonlinear device or to translate one frequency to another using nonlinear mixing. Basically, there are 5 sections to a superheterodyne receiver:

(a) RF section

(b) Mixer/converter section

(c) IF section

(d) AM detector section

(e) Audio section

6-3-3 Image Frequency

An image frequency is any frequency other than the selected radio frequency carrier that, if allowed to enter a receiver and mix with the local oscillator, will produce a cross-product frequency that is equal to the intermediate frequency. It also said to be equivalent to a second radio frequency that will produce an IF an IF that will interfere with the IF from the desired radio frequency.

Once an image frequency has been mixed down to IF, it cannot be filtered out or suppressed.If the selected RF carrier and its image frequency enter a receiver at the same time, they both mix with the local oscillator frequency and produce different frequencies that are equal to the IF.Consequently, two different stations are received and demodulated simultaneously, producing two sets of information frequencies.

Image Frequency and its Rejection

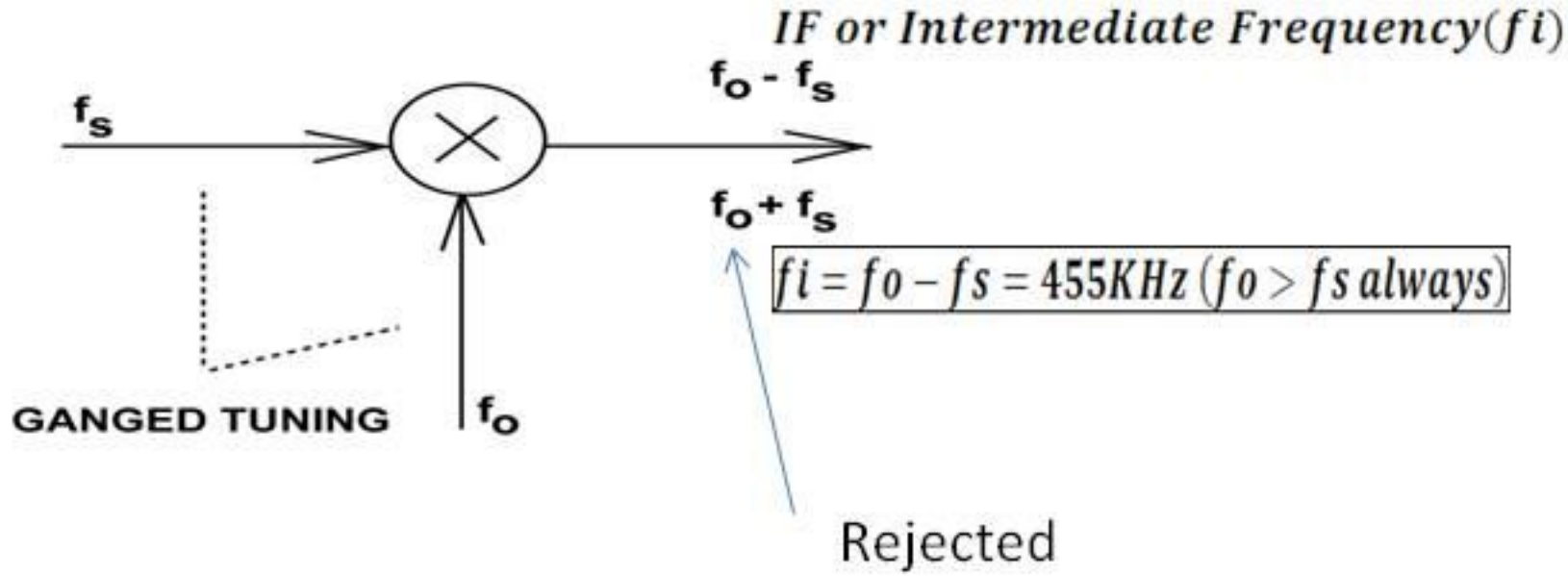
We have seen that super heterodyne Receiver is better than TRF Receiver but it faces a major drawback , this is Image Frequency Problem

For example

Let IF = 500 KHz

So, 500= 1600-1100

And 500= 1100- 600



Therefore, 1100 and 600 KHz are both image Frequency stations.

See formula related to this topic in next slide:

contd.,

$$IF\ or\ Intermediate\ Frequency(fi)$$

$$\boxed{fi = fo - fs = 455KHz\ (fo > fs\ always)}$$

Q. Why $fo > fs\ always$

means local oscillator frequency is kept greater than the incoming signal frequency?
(See class notes for reason)

HINT: $\frac{Cmax}{Cmin} \cong \frac{4}{1}$

Image signal frequency is given by fsi

$$fsi = fo + fi$$

Also , we have $fo = fs + fi$

$$so,\quad fsi = fs + fi + fi$$

$$fsi = fs + 2fi$$

Image Rejection ratio, α is given by: $\alpha = \sqrt{1 + Q^2\,\rho^2}$ where $\rho = \frac{fsi}{fs} - \frac{fs}{fsi}$

Image Station Problem

- While up-converting the desired station to IF, we are, at the same time, down-converting another station to IF as well.
- These two stations are called *image stations*, and they are spaced by 2x455=910kHz.
- Solution:
  Before conversion, use a BPF (at RF) centered at f_c of the desired station.
  The purpose of the filter is NOT to extract the desired station, but to suppress its image. Hence, it does not have to be very sharp.

DESCRIPTION OF EACH BLOCK OF SUPERHETERODYNE RECEIVER:

(It is given in next slides)

Antenna or Aerial:

The receiving antenna intercepts the electromagnetic wave.

Types of Receiving Aerials:

INDOOR AERIALS

- **a. Frame Aerials**
- b. Mesh Aerials
- c. Ferrite Rod Aerials (SEE NEXT SLIDE)
- d. Metallic rod Aerials

OUT DOOR AERIALS

- **a. Vertical Aerials**
- b. Inverted L Aerials
- c. T- Aerials
- d. Dipole Aerials

Characteristic of an ideal Receiving Aerials:

1. It receives all the signal without waveband switching.
2. For broadcast reception it must be omnidirectional characteristics.
3. Small variation in terminal impedence with change of signal frequency.
4. Minimizes Fading.
5. Should be cheap.
6. Minimizes interferences from house wiring etc.
7. Resistant to corrosion or damage by weather.

Ferrite Rod Aerial

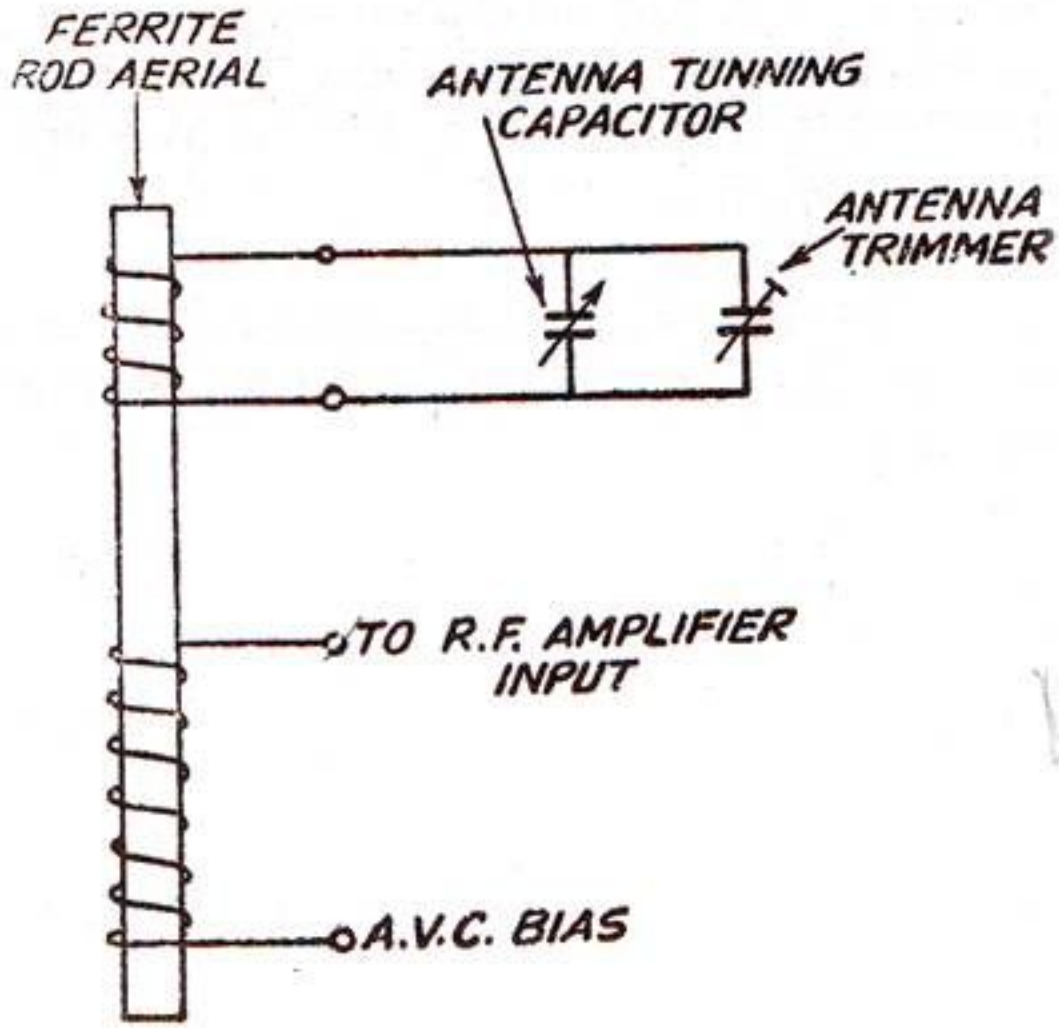


Fig. 9.8. Ferrite rod aerial and its coupling circuit.

The magnetic vector of incident EM wave produces magnetic flux through the ferrite core, since the permeability of ferrite core is very high, there results a very heavy concentration of magnetic flux through the core, this time varying magnetic flux threads through the two section of coil and induces relatively high voltages.

RF Amplifier:

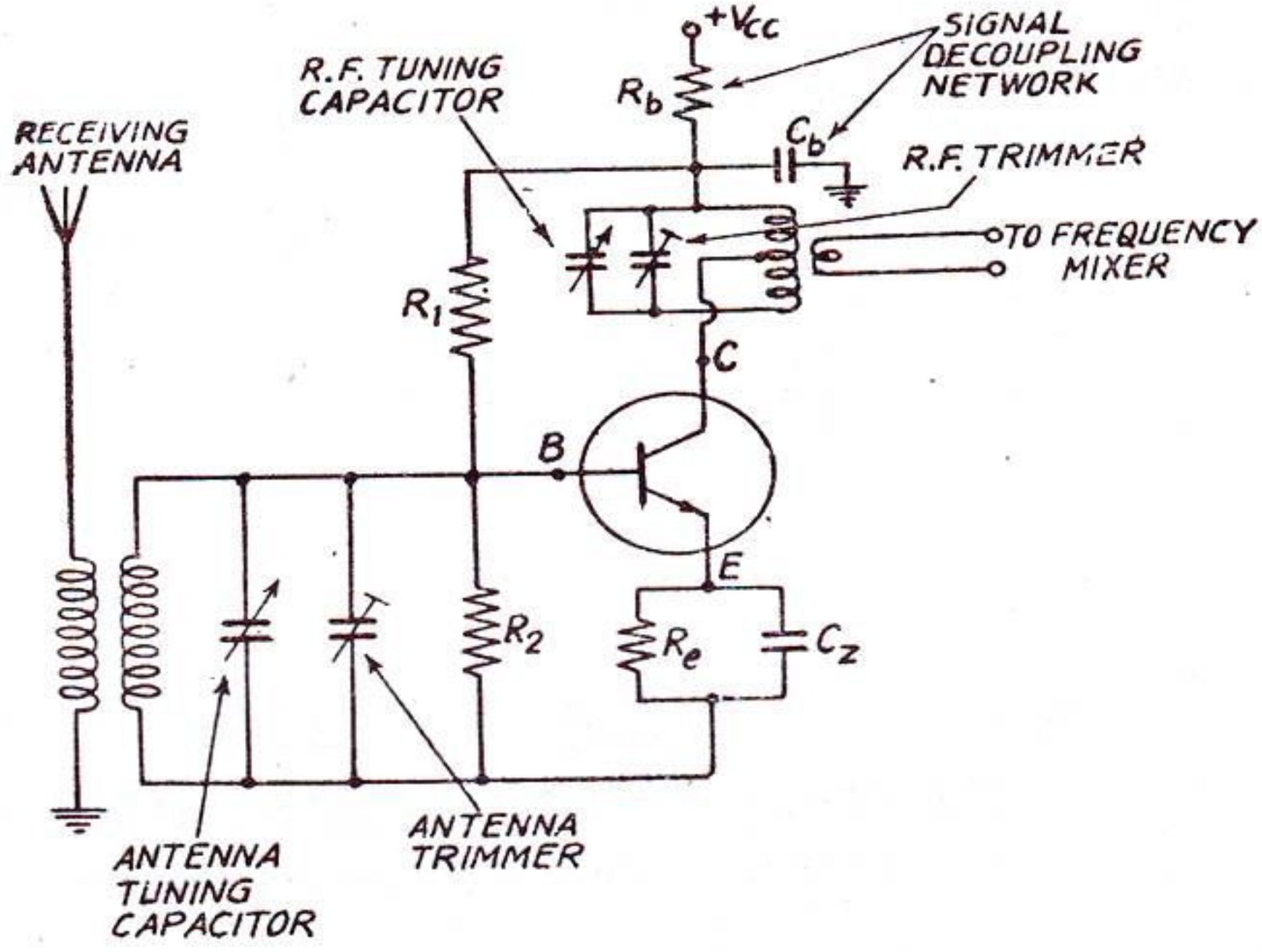
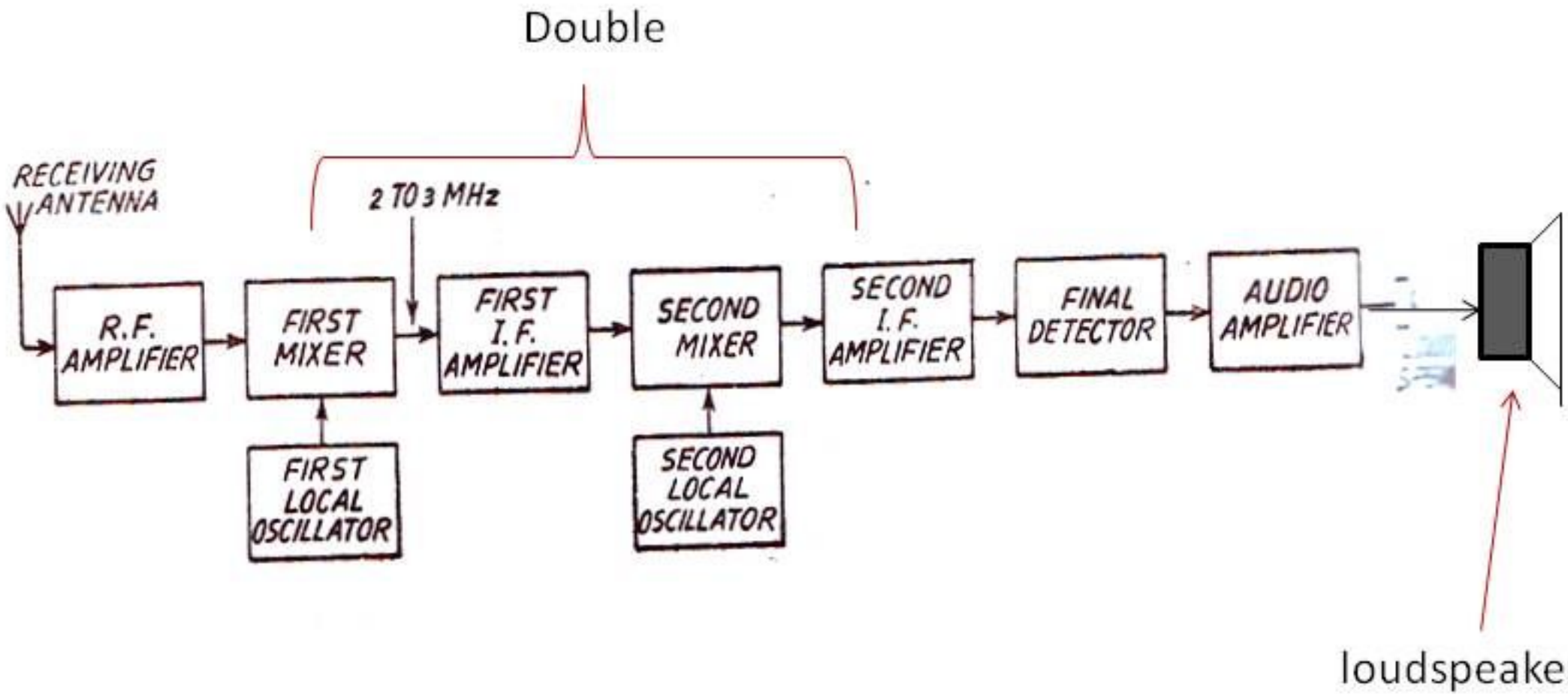


Fig. 9.9. Circuit of R.F. amplifier stage.

Characteristics of a Radio Amplifier

1. Greater Gain i.e, better sensitivity
2. Improved rejection of adjacent undesired signals i.e, better selectivity.
3. Improved signal/ Noise Ratio.
4. Improved Image Frequency Rejection.
5. Improved coupling of receiver to the antenna.
6. Prevention of re-radiation of the local oscillator voltage through the antenna.

Double Super heterodyne Receiver



Frequency Mixer

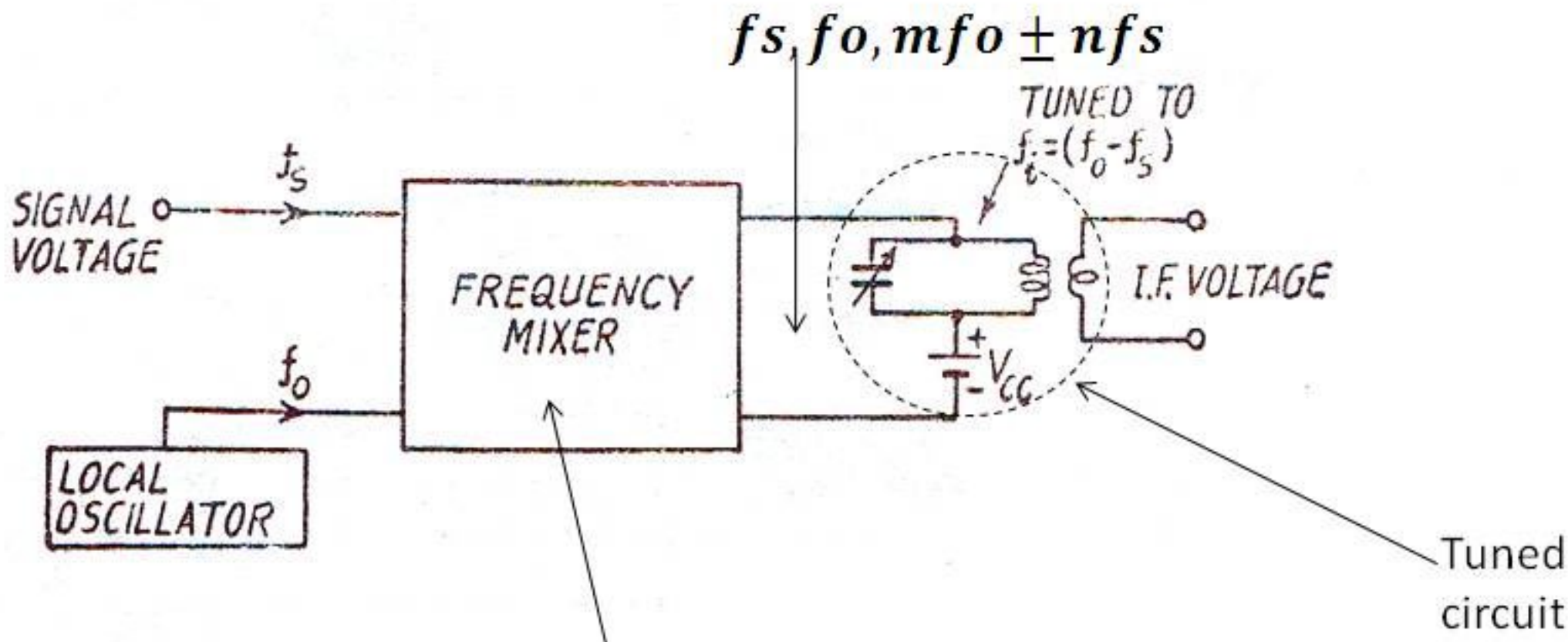


Fig. 9.13. Sehematic diagram of frequency mixer.

Contd.(FRQUENCY MIXER)

A Frequency mixer is a non linear Device which produces a no. of frequencies when two different input are applied at the input of frequency mixers having components at output equal to $fs, fo, mfo \pm nfs$,out of these one of interest is the component of

$$\boxed{fi = fo - fs = 455KHz}$$

Which is called as Intermediate Frequency(IF) , Which is tuned by a tuned circuit outside of the mixer.

CLASSIFICATION OF MIXERS

1. *According to the components being used*

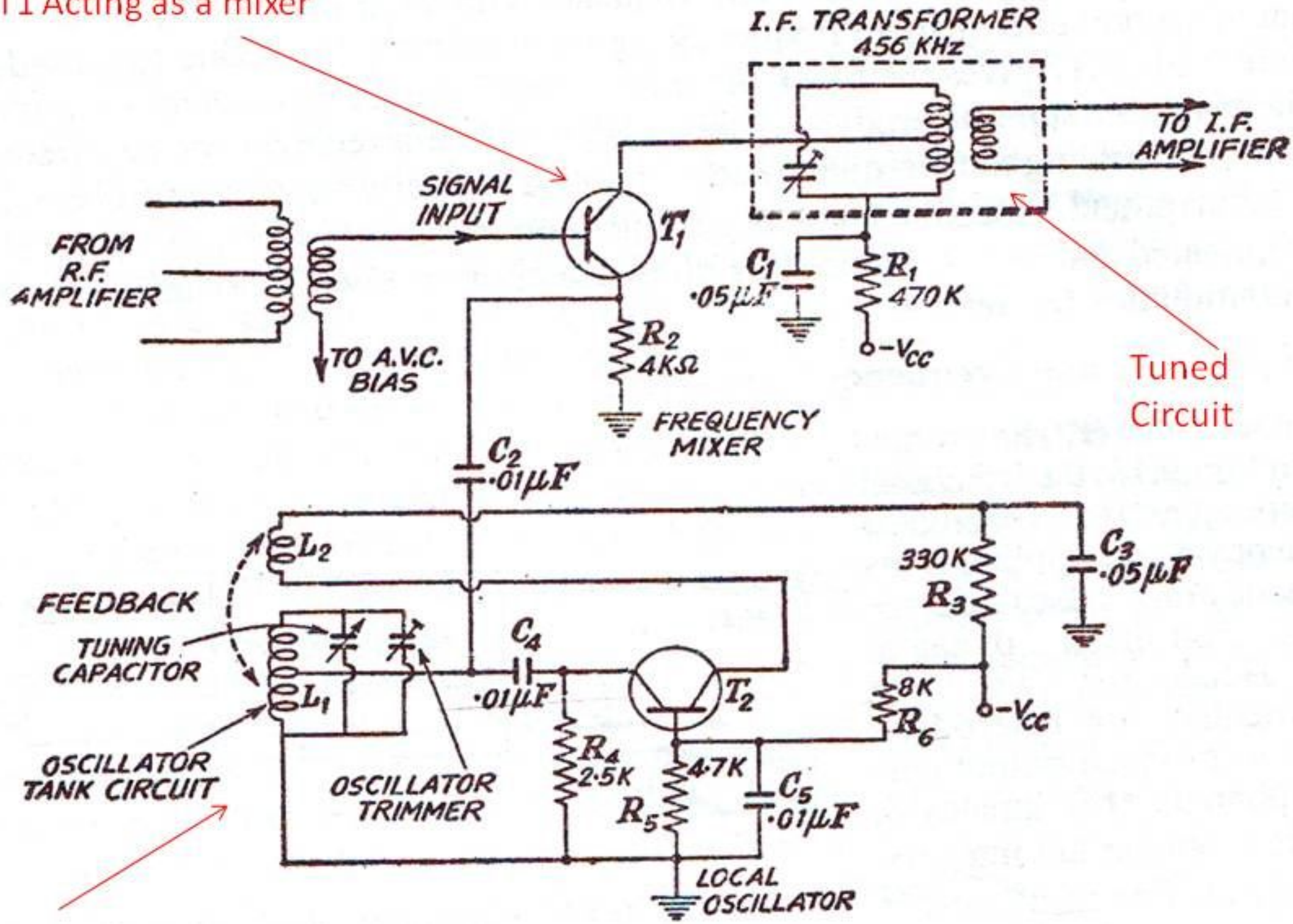
1.1. *Self Excited mixers: Same device act as mixer and as an oscillator, Devices such as BJT,FET,MOSFET used are self excited one (see fig. 9.15 in slide no. 34), where Transistor T1 acting as a part of mixer as well as oscillator*

1.2. *Separately Excited Mixers: Separate device for mixing and as an oscillator, Devices such as Diode used are self excited one (see fig. 9.15 in slide no. 33), where Transistor T1 acting as a part of mixer as well as oscillator*

2. *Switching Mixers*
3. *According to the circuit arrangement*
4. *Frequency mixers*

NOTE : SEE CIRCUIT OF BJT MIXER IN CLASS NOTES.

T1 Acting as a mixer



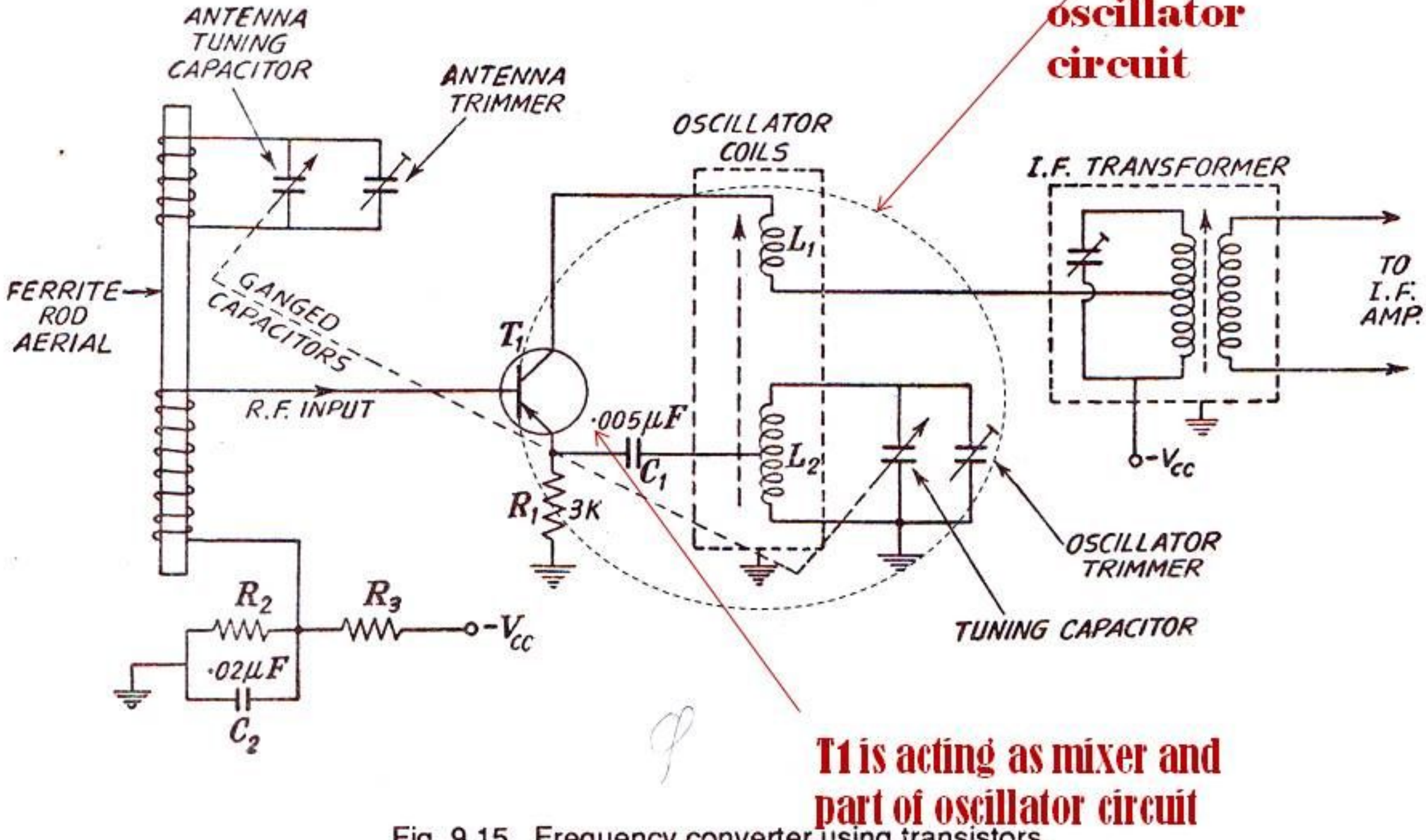
Tuned Circuit

Oscillator circuit

Fig. 9.14. Frequency mixer and oscillator stages using transistors.

Frequency Converter

Mixer and oscillator circuit



T1 is acting as mixer and part of oscillator circuit

Fig. 9.15. Frequency converter using transistors.

OSCILLATOR CIRCUIT TRACKING

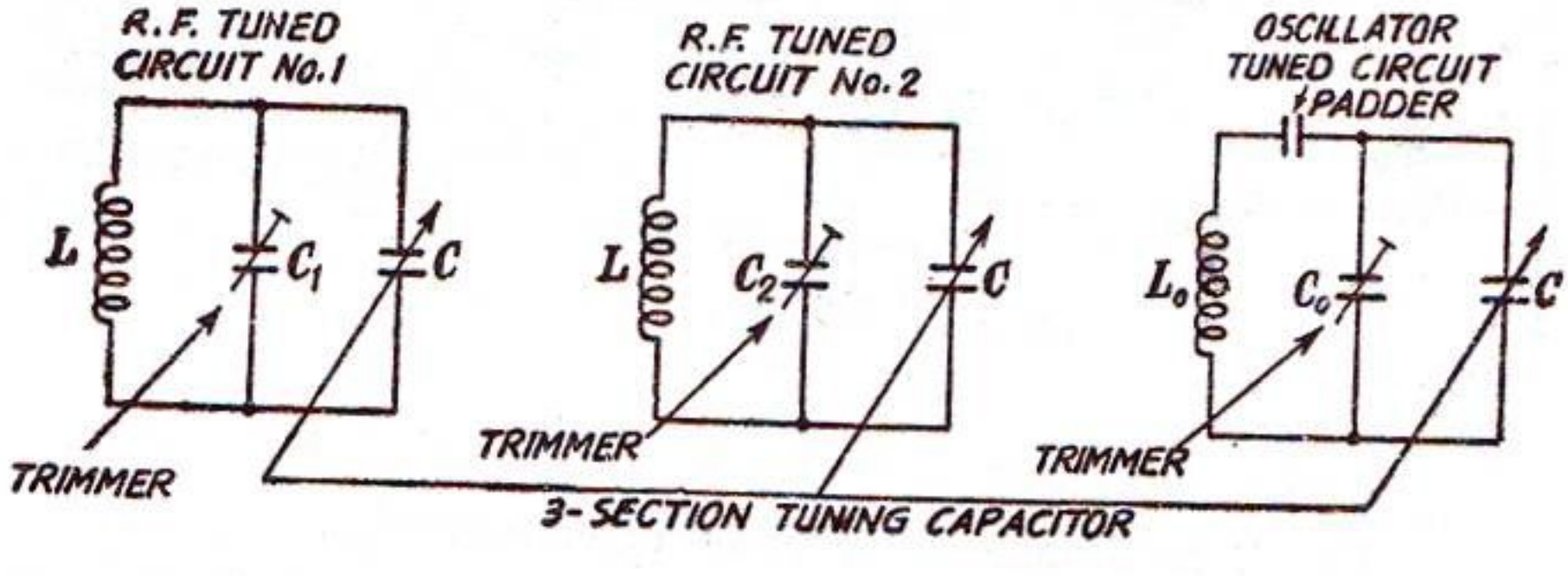
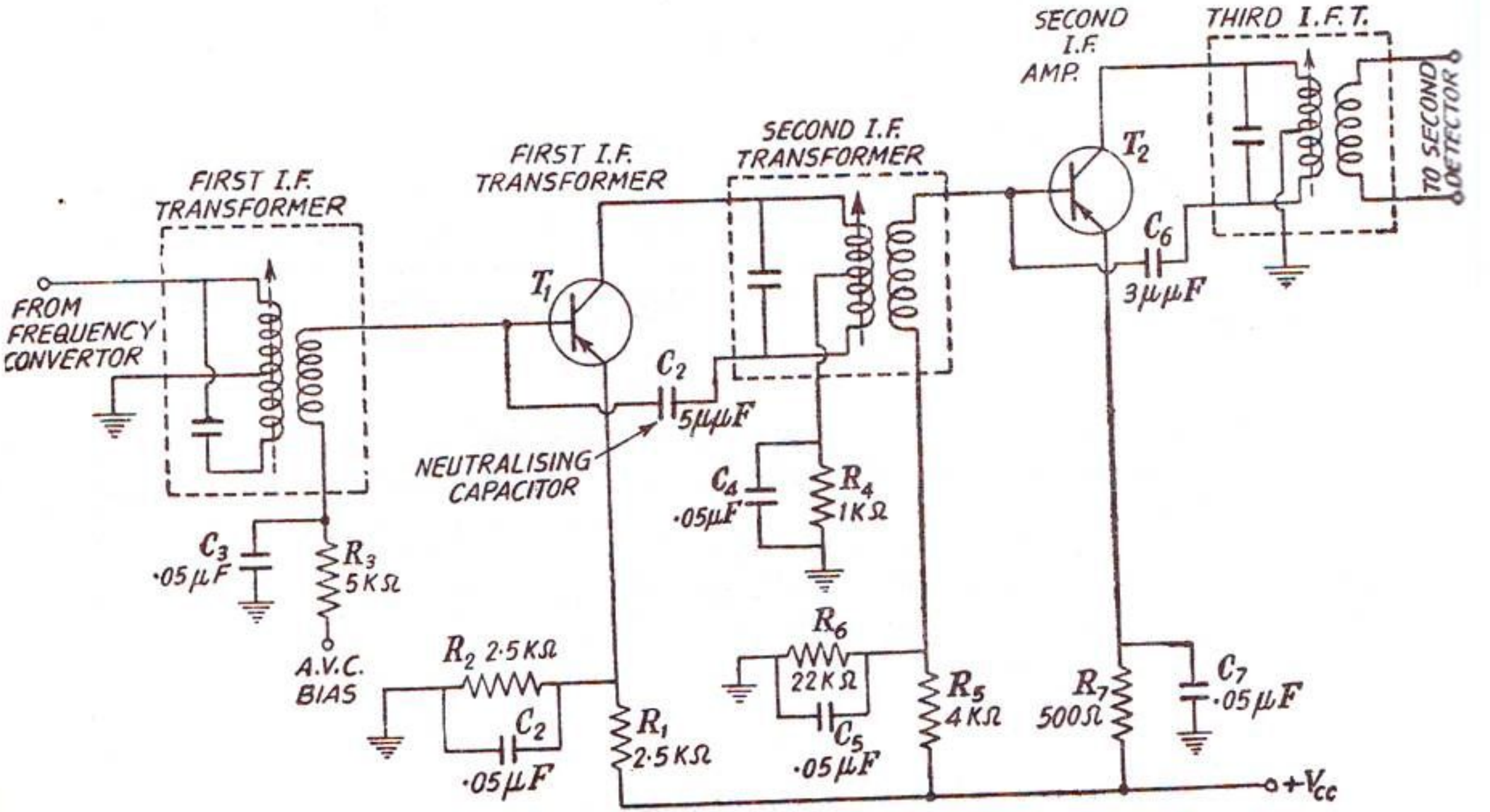


Fig. 9.16. Trimmers and Padder for alignment of R.F. and oscillator tuned circuits.

- Process of tuning circuit to get the desired output is called Tracking
- If any error that exists in the frequency difference will result in incorrect frequency feed into The IF Amplifier called Tracking Error

IF amplifier



Two-stage transistorized I.F. amplifier

DETECTOR STAGE :

- Work on "Charging and discharging the Capacitor"
- Simple circuit
- Noncoherent (No need for synchronization Tx and RX)
- Noisy

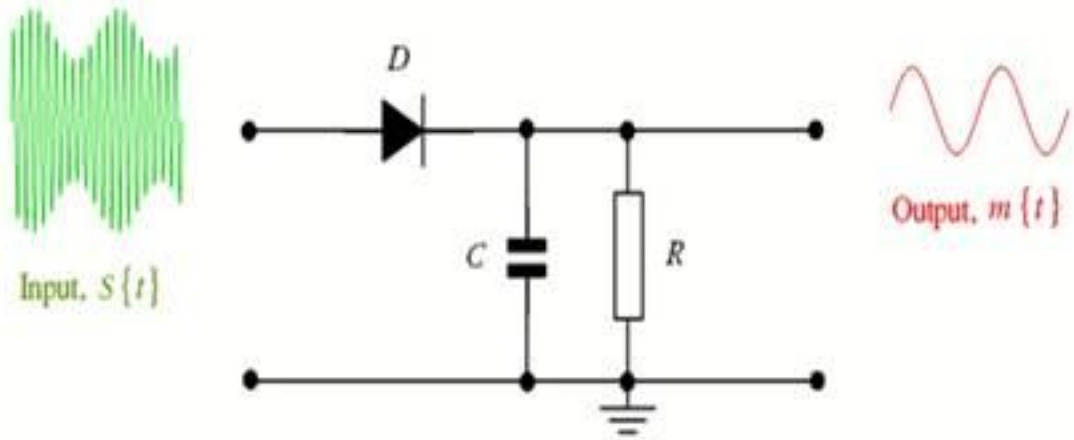


Figure 9.2 Envelope Detector (AM Demodulator/Detector).

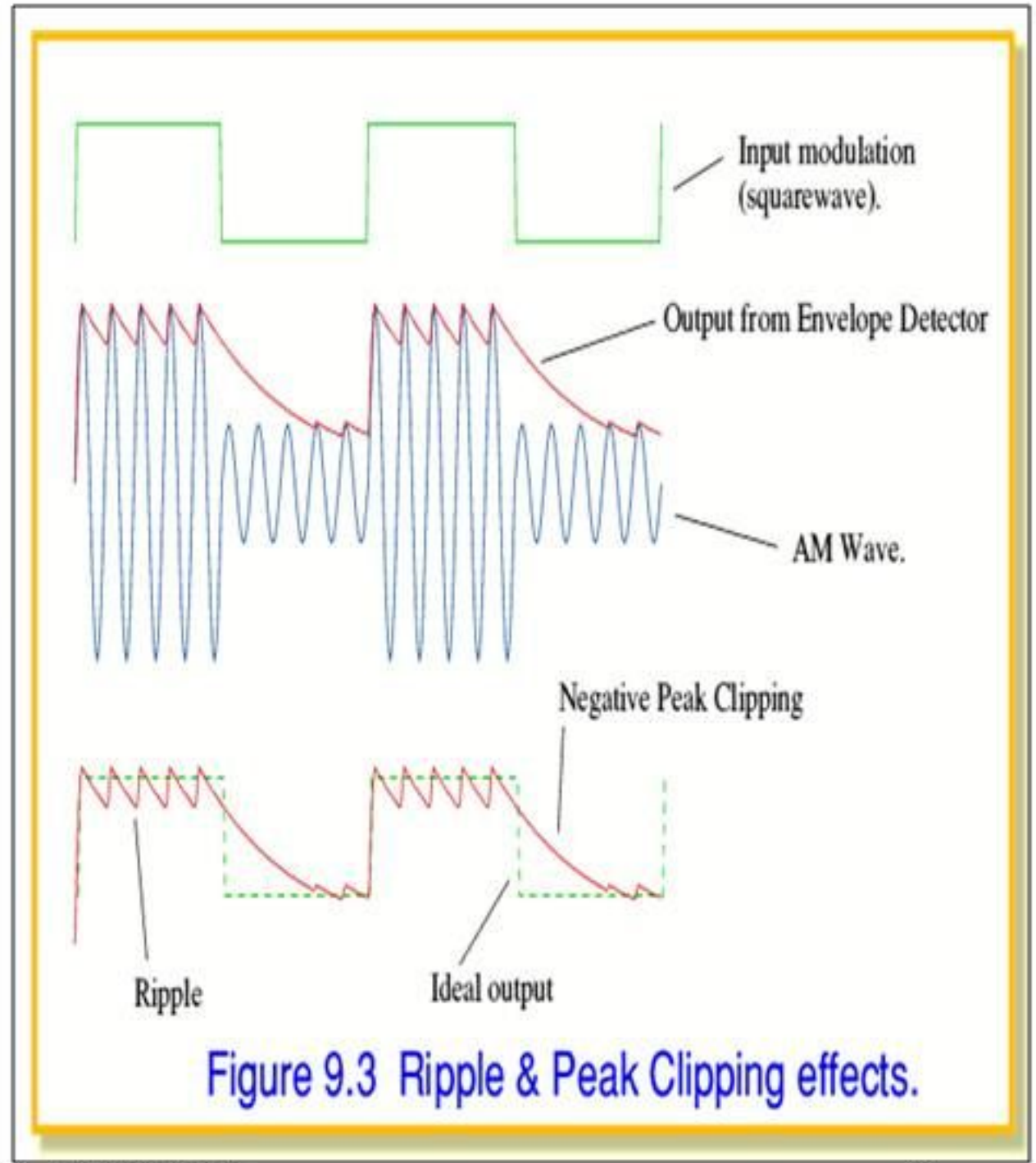


Figure 9.3 Ripple & Peak Clipping effects.

Automatic Volume Control(AVC) or Automatic Gain Control(AGC)

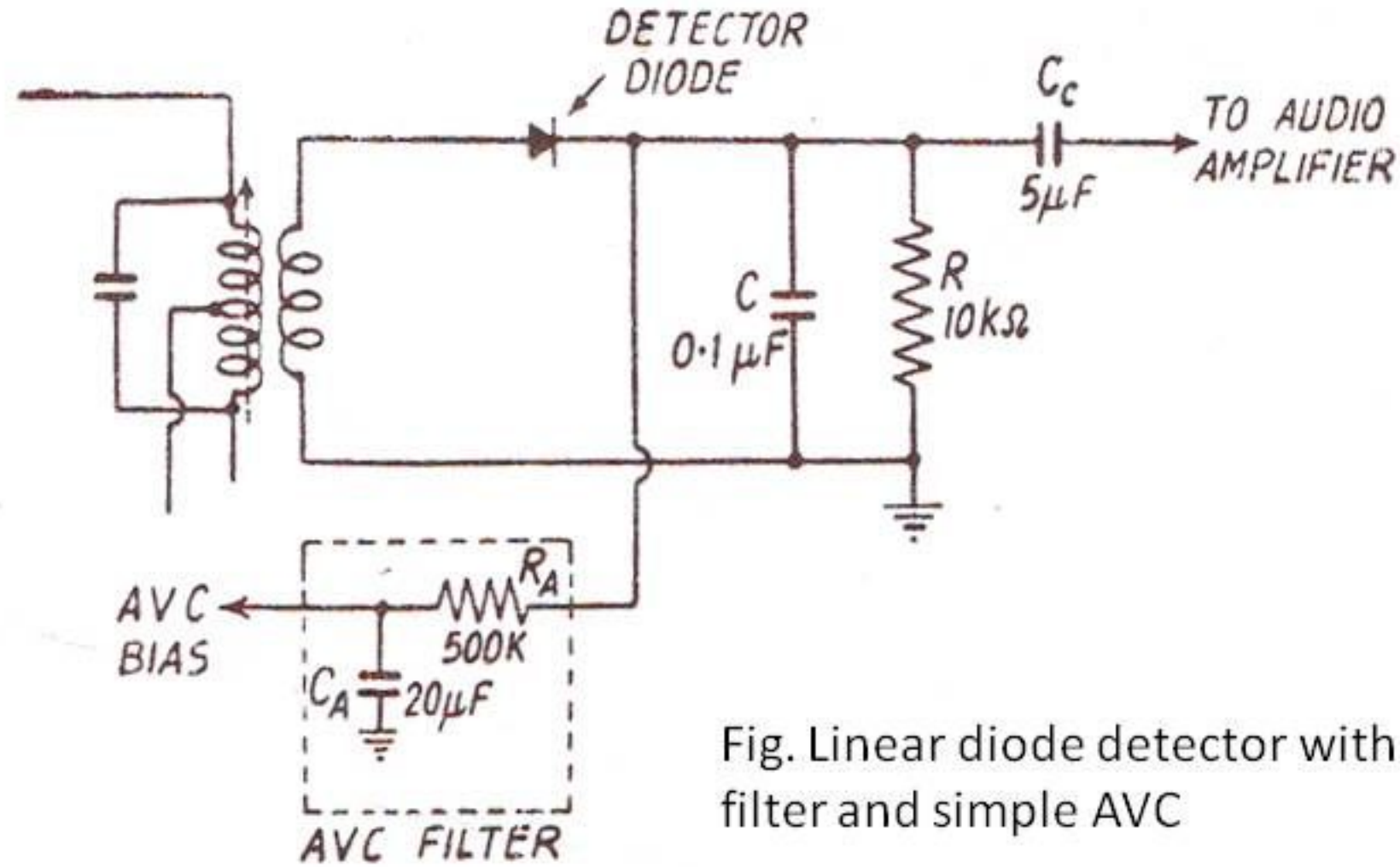


Fig. Linear diode detector with capacitor filter and simple AVC

Contd.

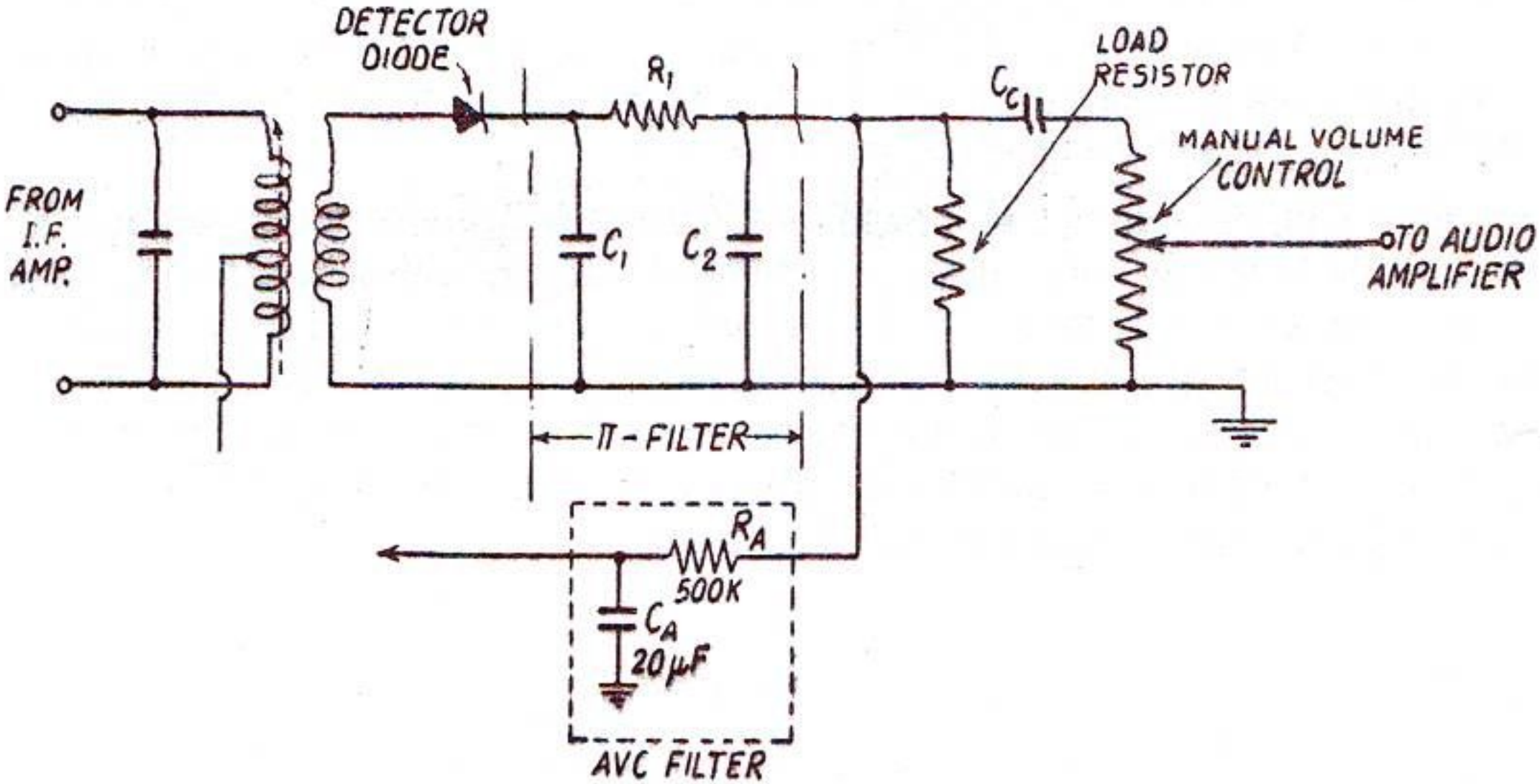


Fig. 9.20. Linear diode detector with π-filter and simple AVC.

Working:

Principle of Automatic Gain Control(AGC):

It consist of following steps:

1. To derive by rectification of carrier voltage in a linear diode Detector, a dc voltage proportional to the carrier amplitude.
2. To apply this voltage as a reversed biased voltage at the input of the RF amplifier, frequency mixer, and the IF amplifier.

Q???.

Q.1. What does the letters AGC stand for?

ANS. Automatic Gain Control

Q. 2. What is the purpose of the Automatic Gain Control?

ANS. Levels out variations in received signal strength by varying gain

Q.3. In what stage of the Super heterodyne Receiver is the AGC voltage developed?

ANS. Detector

Q.4. What stage or stages of the Super heterodyne Receiver is the AGC voltage applied to?

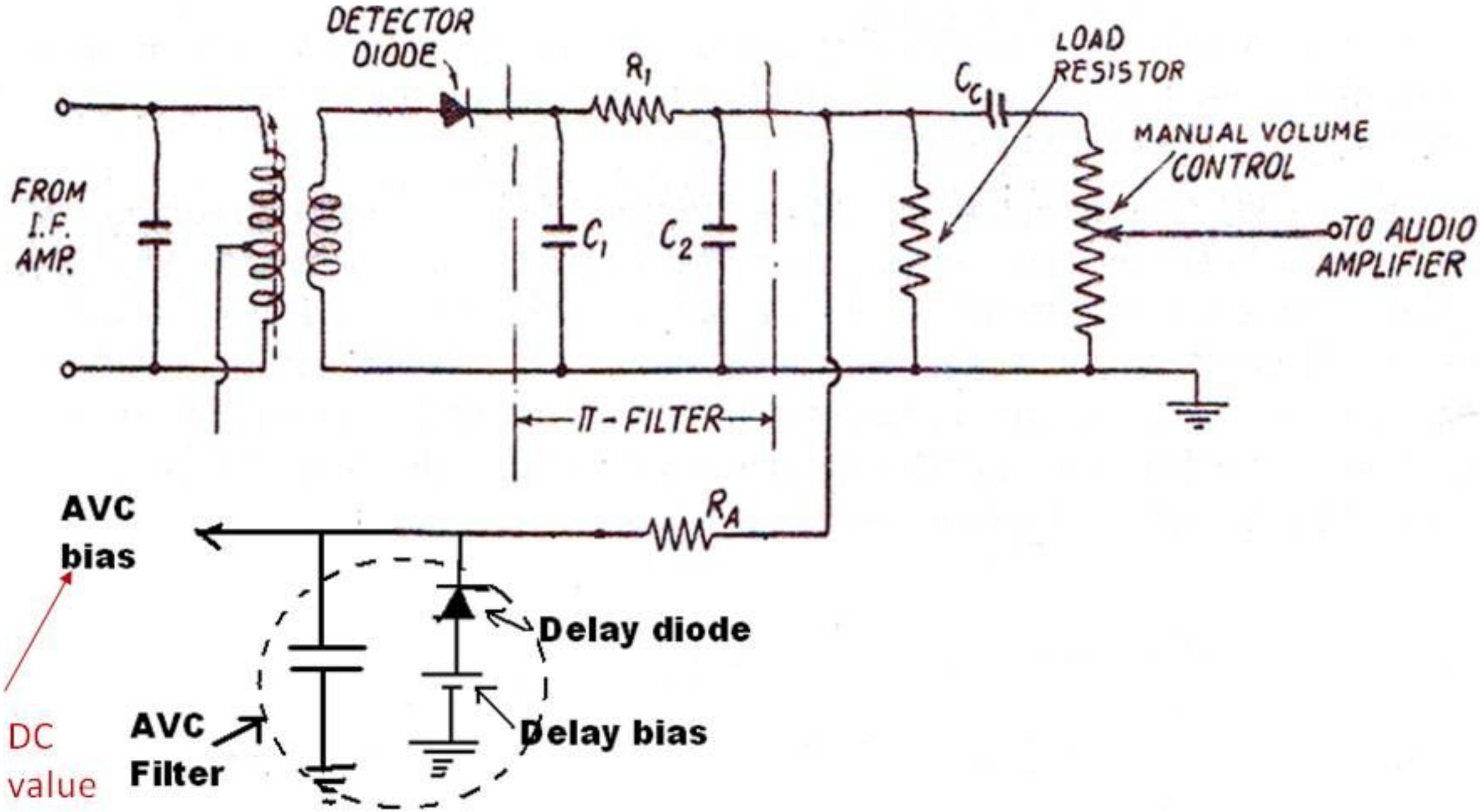
ANS. RF and/or IF stages

Q.5. As the AGC voltage increases, the gain of the amplifier being controlled _____.

ANS. decreases

Delayed AVC:

See class notes or refer
FIG. 9.22 page no. 205/ GK MITHAL



Tone Compensated Volume Control

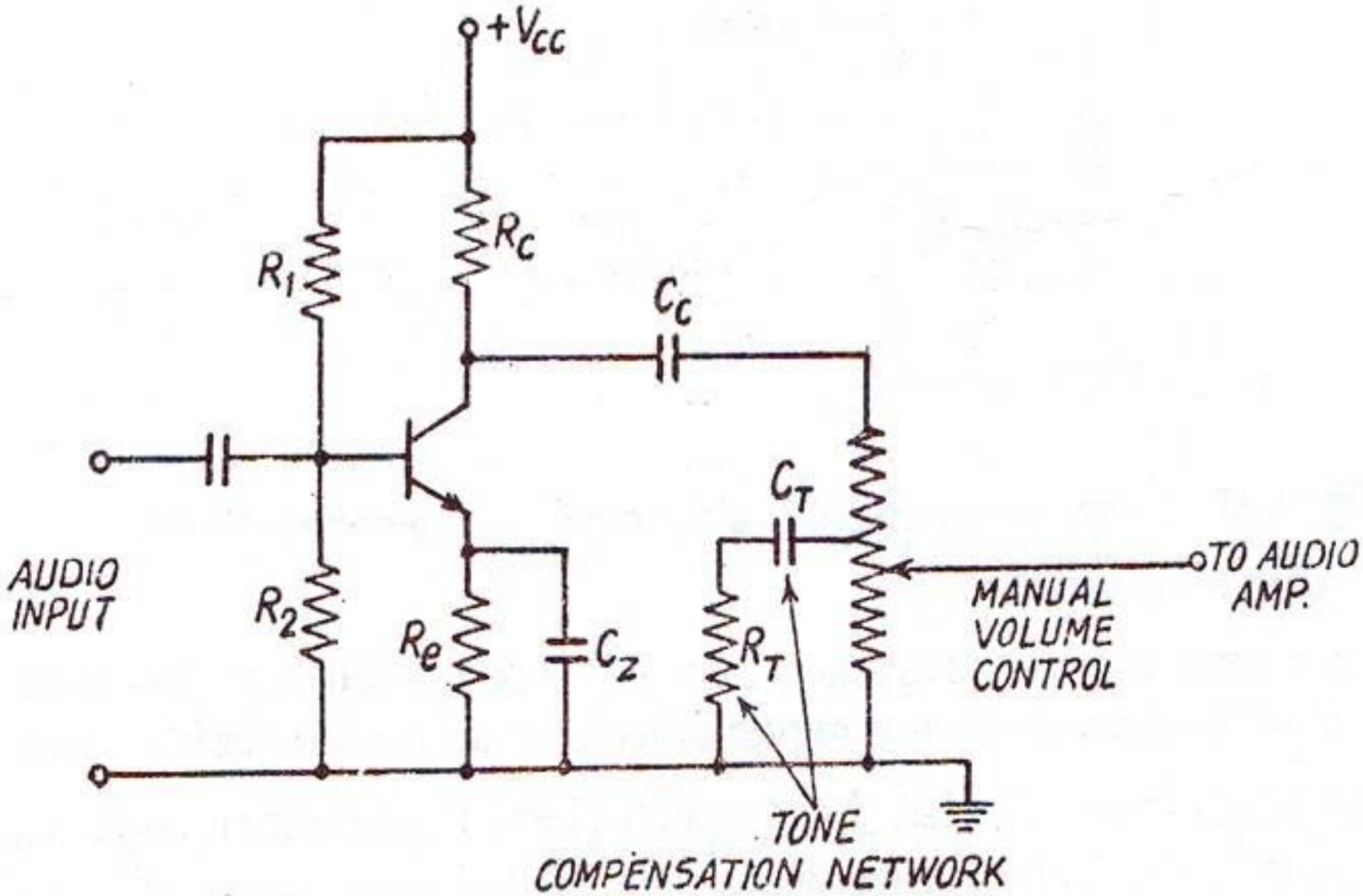
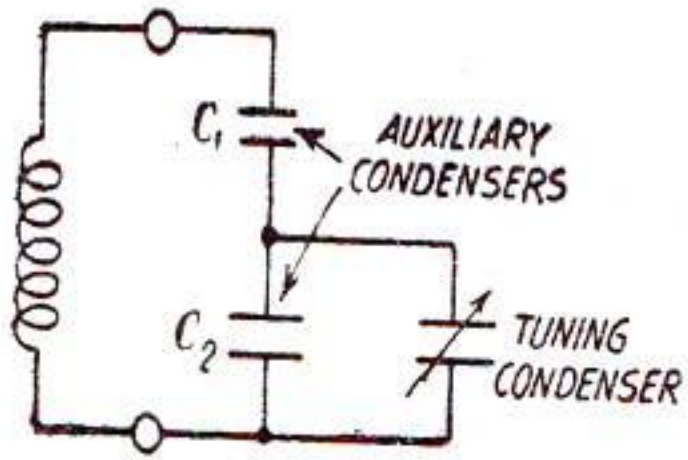


Fig. 9.25. Tone compensated manual volume control.

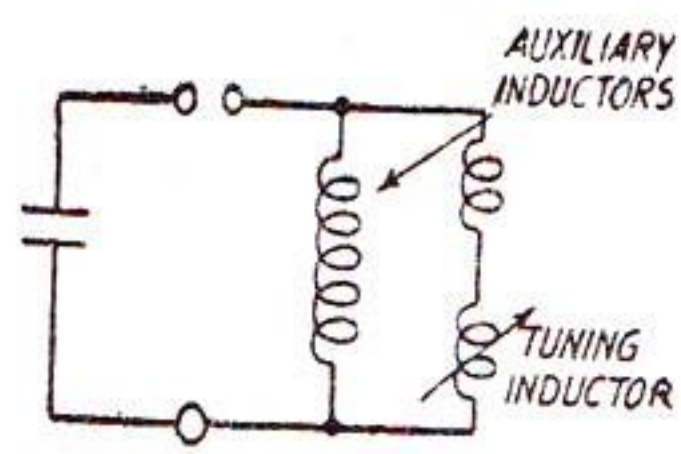
BAND SPREAD TUNING

Spread out the tuning range as to select desired value of tuning frequency, this is done in two ways:

1. By fine tuning to coarse or main tuning control. This is generally applied in receiver system.
2. By allocating full tuning band to a small range of frequency.



(a) Bandspread with condenser tuning.



(b) Bandspread with permeability tuning.

Fig. 9.28. Bandspread tuning by switching in auxiliary reactances.

Noise Limiter

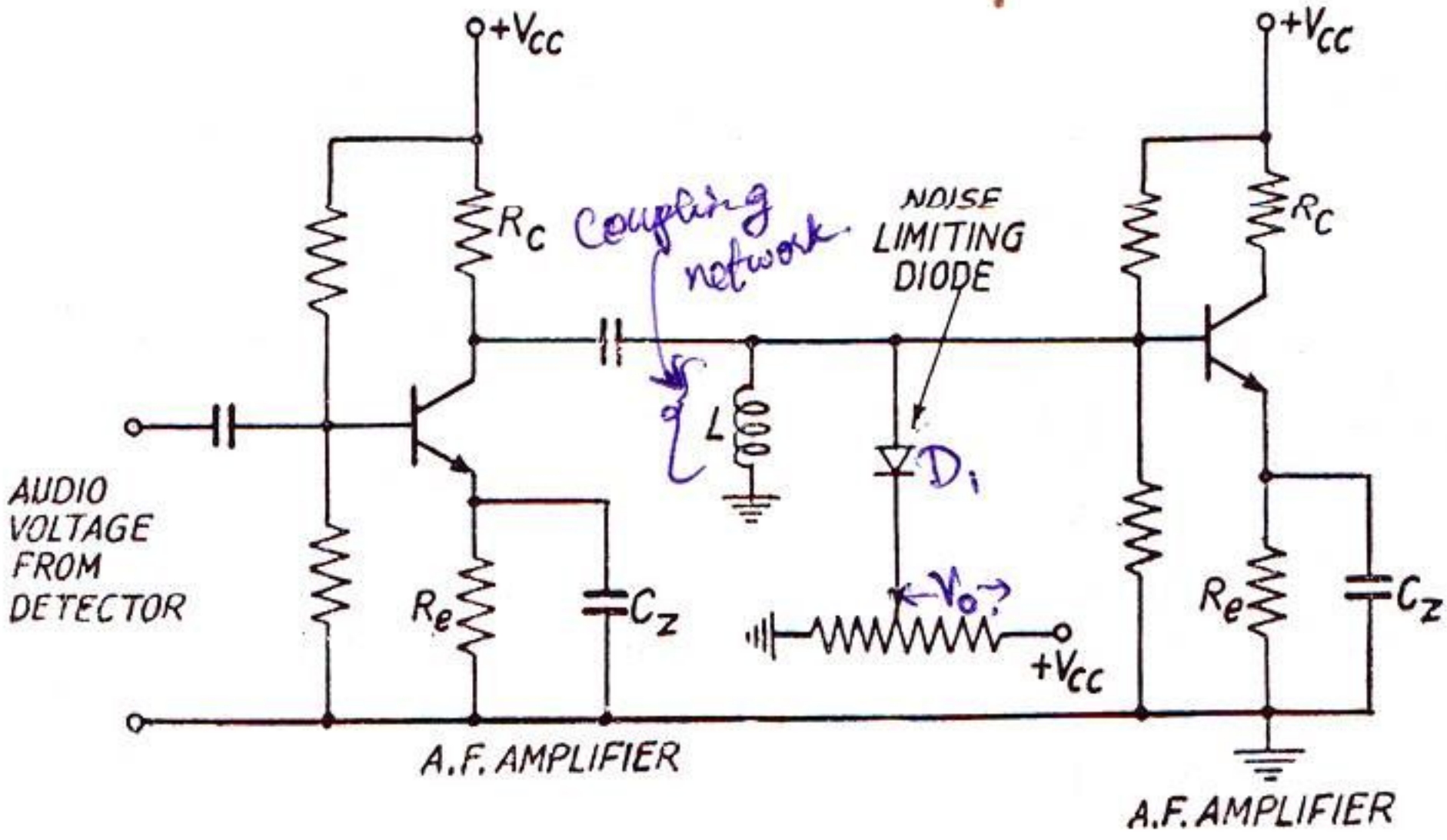


Fig. 9.30. Circuit of a simple noise limiter.

Automatic Frequency Control(AFC)

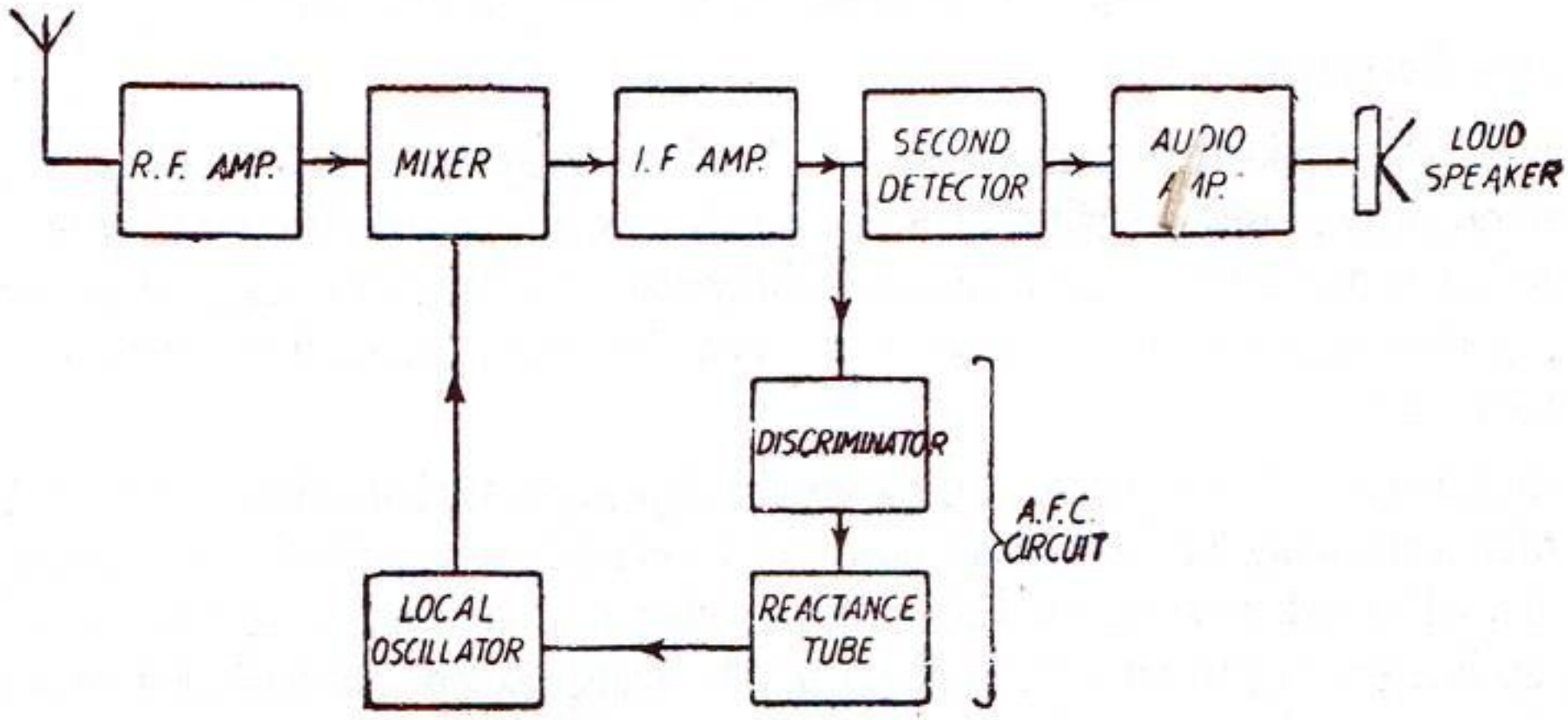


Fig. 9.32. Block diagram of superheterodyne receiver with AFC system.

Inter channel noise suppressor

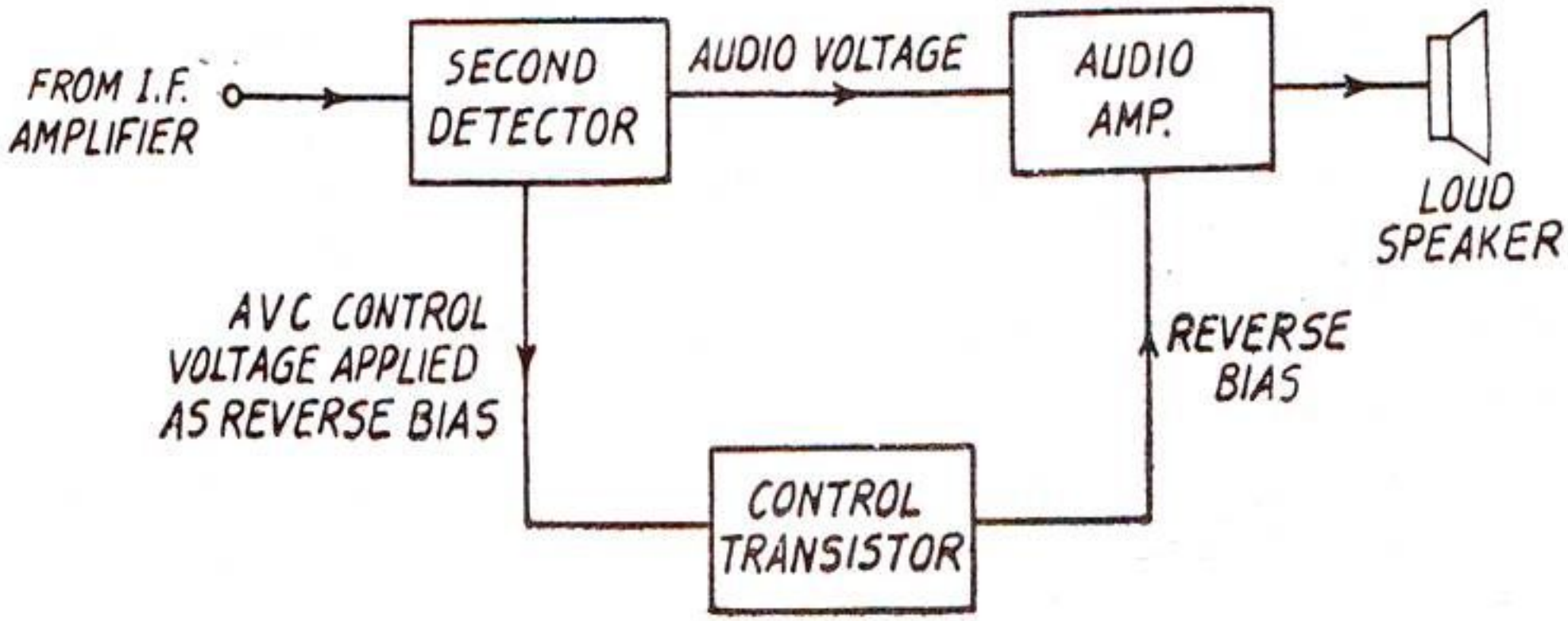
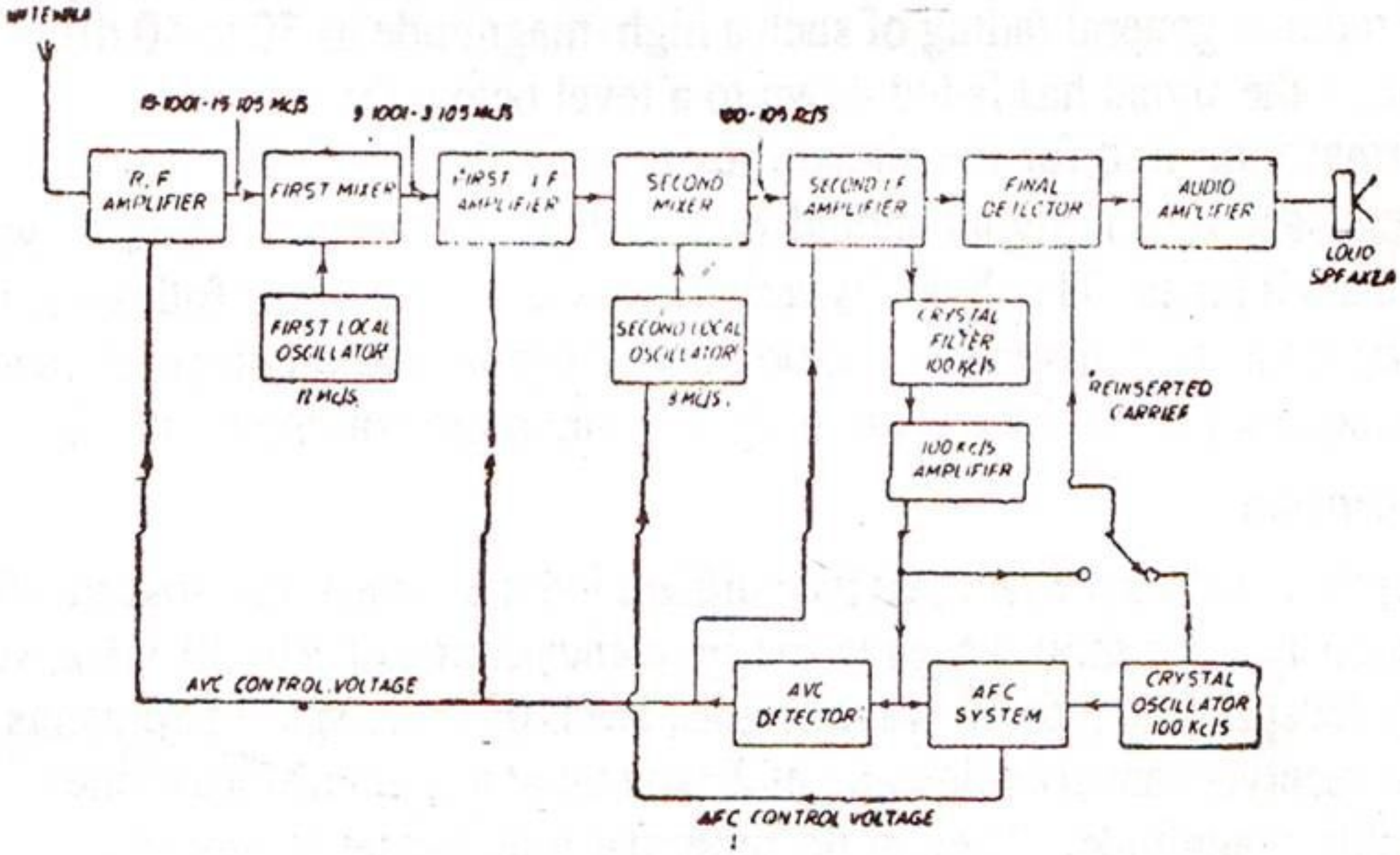


Fig. 9.33. Block diagram of simple squelch system.

SSB RECIEVER



VOLUME EXPANDER:

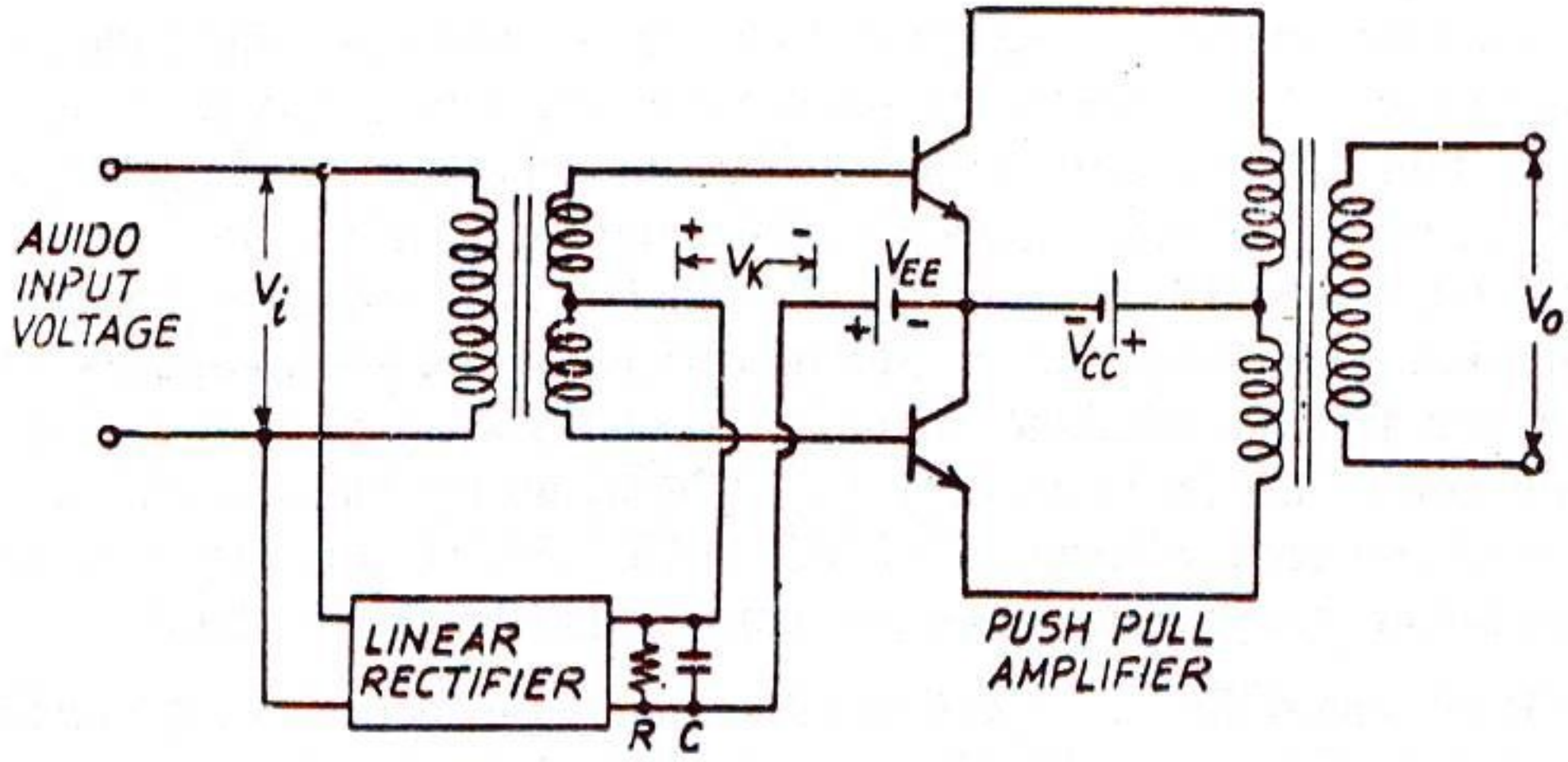


Fig. 9.35. Circuit of a simple volume expander.

Diversity Reception

Diversity Reception system ensures a reasonably high signal level at all times inspite of fading.

They are of generally two types used. They are:

1. Space diversity Reception
2. Frequency diversity Reception

Space Diversity reception System

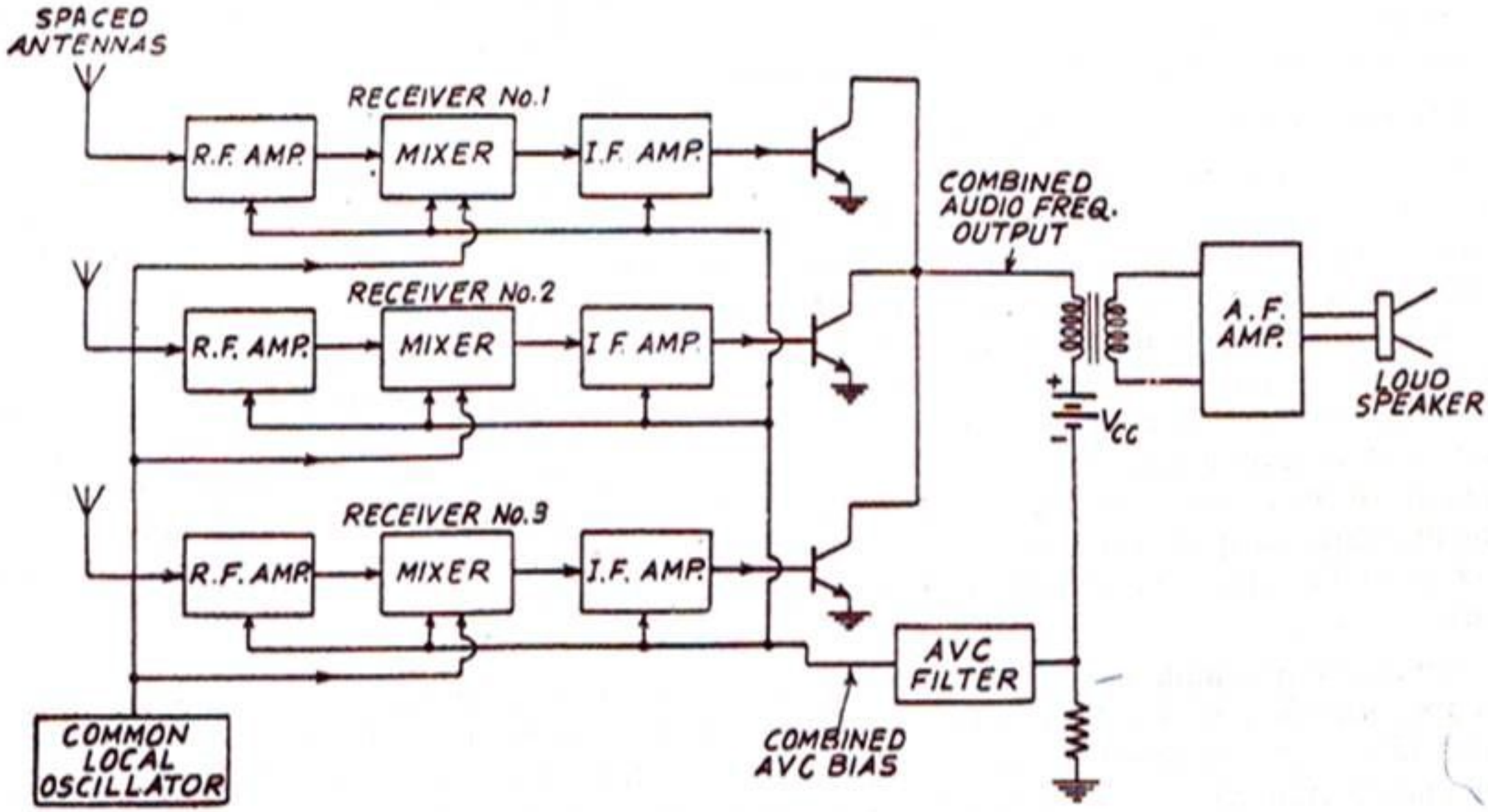


Fig. 9.36. Block diagram of space diversity radio telephone receiver.

MUSA system:

(Multi unit Steerable Antenna System)

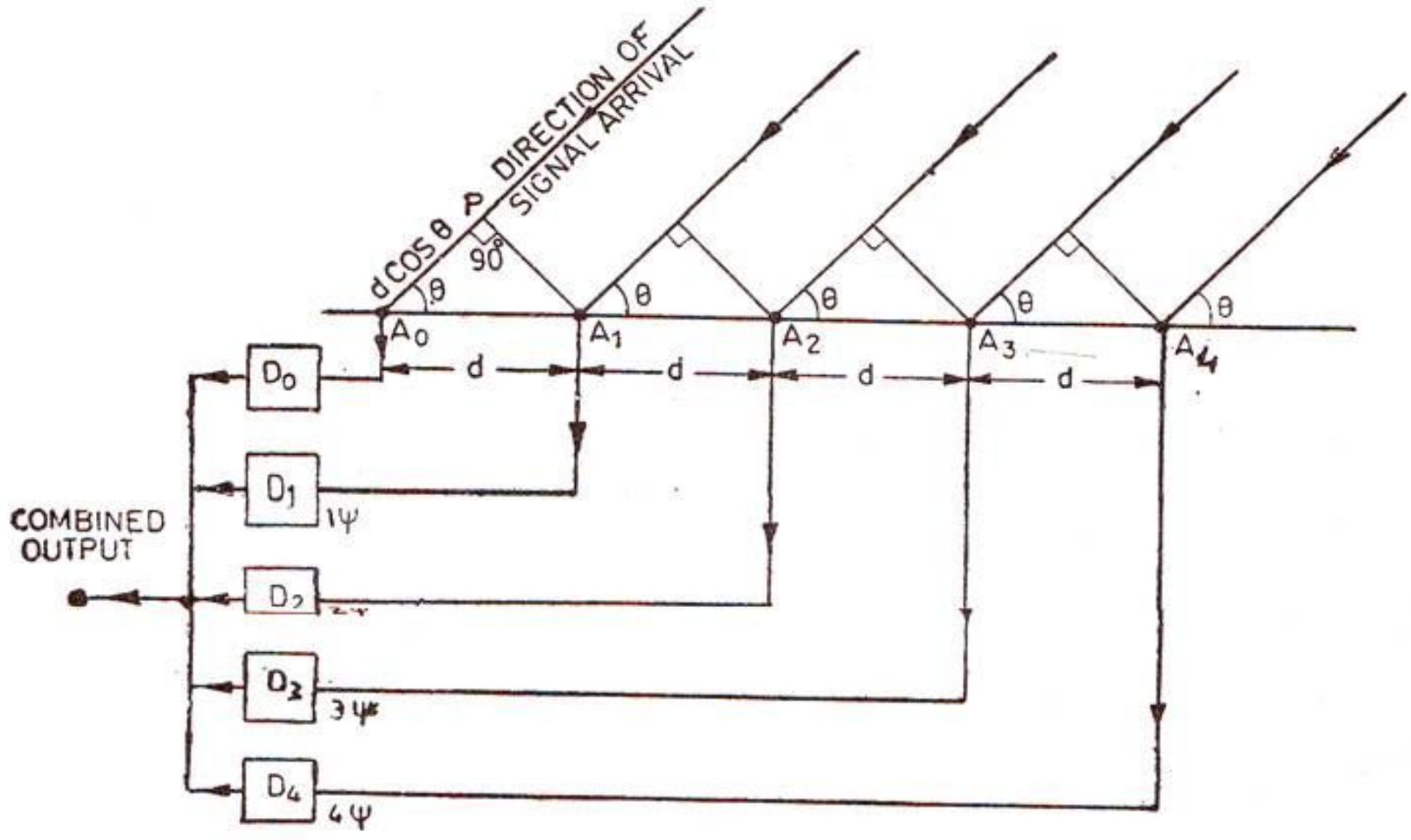


Fig. 9.38. Diagram showing the principle of multi-units steering.

BLOCK DIAGARM OF MUSA SYSTEM

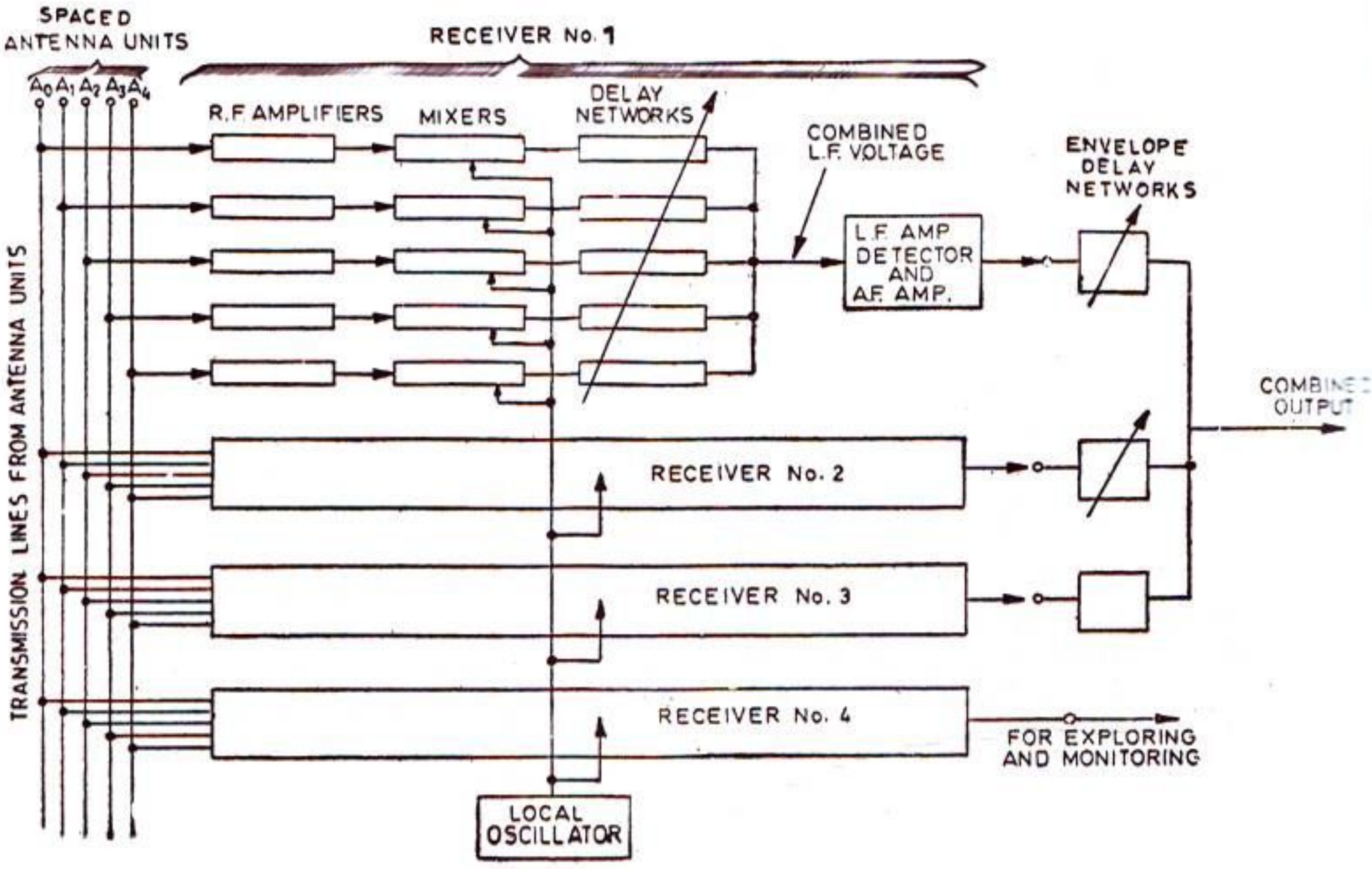


Fig 9.39. Circuit diagram of MUSA system.

Any Questions???

THANK YOU……!!!!!!!!!!

References:

- Radio Engg.: By G K Mithal
- Electronic Communication : By George Kennedy